CONTRIBUTIONS TO THE KNOWLEDGE OF THE MAMMALS OF THE PLEISTOCENE OF NORTH AMERICA.

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INTRODUCTION.

The results detailed on the following pages have been obtained in the course of the writer's investigations on the Vertebrata of the Pleistocene epoch in North America. These results include descriptions of two extinct horses, one new extinct bison, one new and one already-described musk ox, measurements of certain limb bones of fossil horses, and discussion of the meaning of the variations observed. Also there have been secured measurements from many skulls of various equids, as of Przevalsky's horse, of a number of fossil horses, of many domestic horses, of three species of zebras, of the domestic ass, of the chigetai (*Equus hemionus*), and of the kiang (*E. kiang*). A considerable number of these measurements have been quoted from other authors, but many have been made by the writer on skulls which belong to the United States National Museum and to the American Museum of Natural History, and on a fossil skull in the University of Kansas. From these measurements certain indices in use in equine craniometry have been computed. From these measurements and indices an attempt has been made to determine to what extent the various unmixed and wild species which are considered deviate from an average condition; likewise, to ascertain the value of some of the measurements and indices which have been employed in the study of domestic horses; and, finally, an endeavor has been made to throw some light on the elements which have contributed to the formation of that assemblage of horses which bears the name *Equus caballus*.

The writer acknowledges his obligations to the institutions which have kindly and freely granted him access to their materials.

1. DESCRIPTIONS OF A BISON AND TWO MUSK OXEN.

BISON SYLVESTRIS, new species.

Diagnoses.—A bison of the late Pleistocene, having the horn cores feeble, even in case the type was a female, and apparently directed outward in a plane at right angles with the axis of the skull. Pterygoid processes relatively short. Foramen ovale confluent with the foramen lacerum medius. Forehead in front of horn cores narrower than the skull across the zygomatic arches.

Type.—Some portions of the rear of the skull and a part of the right ramus of the lower jaw containing the last premolar and the anterior two molars. Found in Huron County, Ohio.

The writer received for examination, on May 2, 1914, from Hon. C. H. Gallup, of Norwalk, Ohio, a small package of fossil bones which had belonged to some bovine animal. These had been found in a tamarack swamp at some place not yet exactly ascertained in Huron County, Ohio. In the same swamp had been discovered bones of a megalonyx, and in the course of a search for other parts of the skeleton of this animal those of the bovine had been met with. A piece of soil inclosing the bones was sent with them, and it is found to be composed of a mixture of vegetable matter and fine mineral materials. The bones consist of a fragment of the right side of the skull bearing the pedestal of the horn core, another fragment showing the axial region, the left glenoid fossa, etc., and a part of the right ramus of the lower jaw, with some teeth. A study of the specimen shows that they belonged to a hitherto undescribed species of the genus Bison. The writer proposes to give it the name *Bison sylvestris.*

The piece of skull (pl. 30, fig. 1) which presents the pedestal of the right horn core is 91 mm. in its greatest dimension. It consists of a triangular piece of the frontal, a portion of the parietal forming the side wall of the temporal fossa, and a part of the occiput. The interior of this mass is full of air cells, but these hardly extended beyond the base of the pedestal. The pedestal itself is placed well in front of the occipital crest, so that we may be sure that the animal was not a species of *Bos.*

Through some means the pedestal has been broken or gnawed or eroded off so as to be wedge shaped at the extremity. No part of the horn-core itself appears. The pedestal has a diameter of 25 mm. only; hence the horn-core and the horn were evidently very small. It seems pretty certain that the animal was a female. The horn-core was probably directed somewhat upward, as well as outward. It appears also to have started out at right angles, or nearly so, with the median plane of the skull, as in *Bison antiquus.* In other species of American bison, recent and fossil, the horn-cores are directed outward and somewhat backward. The parietal of the specimen under consideration runs forward from the rear of the temporal fossa a distance of 66mm., nearly the same as in the skull of the jersey cow with which it is compared. The suture between the frontal and the parietal extends forward well in front of the pedestal of the horn-core, then turns downward so as to approach rather rapidly the parieto-squamosal suture. This course is quite different from that followed in the existing American bison. In this bison the suture continues forward to opposite the middle of the pedestal or hardly so far, and then descends toward the parieto-squamosal suture; and the point where the suture turns downward seems not to be affected by the size of the horn-core. The anterior end of the parietal in the fossa of the fossil bison is narrow and somewhat prolonged. The horizontal part of the parieto-frontal suture has the same length as in the jersey cow; but, since in the latter the horn is situated farther backward, the point where the suture turns downward is much farther in front of the horn than in the fossil bison. It is noted, too, that in the latter the roof of the temporal fossa extends out on the base of the pedestal, but it does not do so in the jersey skull.

That part of the parietal of the fossil which enters into the occiput is 23 mm. wide and rather rough, and it appears to have formed a part of the occipital crest.

The larger fragment (pl. 30, fig. 2) presents a part of the base of the skull, including the left occipital condyle and a part of the right; most of the basioccipital and the basisphenoid; that part of the left squamosal which enters into the glenoid fossa and the zygomatic arch; and a part of the auditory apparatus. For our understanding of the skull it would have been better if the two fragments had belonged to the same side, for both reach the suture between the parietal and the squamosal, in the temporal fossa.

The distance from the median point on the lower lip of the foramen magnum to the front of the basisphenoid is 85 mm., as in the jersey cow. In the skull of a cow buffalo (No. 15690, National Museum), whose basilar length is 423 mm. and whose upper tooth line is 148 mm. and whose width of skull at the zygomatic arches is 205 mm., the distance forward to the front of the basisphenoid is 98 mm. The width across the occipital condyles can not be exactly determined, but it was about 96 mm.; that of the jersey being 93 mm.; that of the small buffalo cow just mentioned, 110 mm. The width across the tuberosities on the basioccipital was close to 56 mm.; in the jersey 45 mm.; in a large bison 62 mm.; in another bison 57 mm. In the jersey cow and in the American bison there are tuberosities on the basisphenoid which sometimes are hardly more than rough surfaces, but which may form considerable processes. In the fossil under consideration, these form two platelike processes of bone. These are about 25 mm. long at their bases, extend downward about 12 mm. from the lower surface of the basisphenoid, and are 4 mm. or 5 mm. thick. They diverge from each other and leave a channel between them into which one may lay one's little finger. When enlarged, in the bison, these tuberosities are quite thick and are probably never so high. How much variation in this respect there was in the new species one can not yet know.

The pterygoid processes of the alisphenoid have the appearance of having been quite different from those of both the existing bison and the jersey cow. In both the latter animals these processes extend far downward and forward from their bases, 45 mm. in the jersey, 60 mm. in the small cow buffalo mentioned above. In this latter specimen each process has, very close to its distal end, a width of 21 mm. In our fossil species these processes appear to have been only about 20 mm. long, in this respect resembling some of the antelopes; and they come to a point in front. It is possible that a thin edge has disappeared, but there is no evidence of it. On the inner face of the front edge there appears to be a sutural surface for union with the palatine and the pterygoid. This front edge slopes directly downward and meets the descending hinder border, so that the process is triangular. The base of the process is about 18 mm. long. The hinder border is acute; while in both the jersey and the American bison it is thick and obtuse.

The region at the inner extremity of the petrous bone and in front of it appears to have been extremely different from that usually seen in artiodactyls. In the jersey and the existing bison and nearly all other artiodactyls the foramen ovale is inclosed by the alisphenoid. While the bar of the bone on the outer border of the foramen in the bison is narrow, it is thick, 5 mm. or more, on the inside nearly 10 mm. In the jersey, too, the bone is thick all around the opening. In both these animals the foramen lacerum medius is cut off from the ovale by a wide stretch of bone belonging to the alisphenoid. On the other hand, in the fossil here described the region in front of the petrosal is widely open; and, apparently, the two foramina mentioned formed one. The alisphenoid certainly appears not to have sent a prong of bone around the outer side of the foramen ovale. The bone forming the front boundary of this foramen comes down to a thin acute edge, and when it is followed around to meet the squamosal the alisphenoid appears to have stopped there. The opening which represents the two foramina mentioned extends backward 27 mm. to the bone. Backward it widens to nearly 25 mm. The hinder part of this gap was, of course, occupied by a part of the bulla. It is possible that the outer edge of the basisphenoid extended into the opening and restricted it somewhat, but there is little or no evidence of it. It is more likely that the inner border of the squamosal extended inward farther and narrowed the foramen somewhat. In the antelope *Taurotragus* the foramen ovale is sometimes large and the alisphenoid bar on its outer border is interrupted, but always this foramen is closed behind by a union of the alisphenoid with the squamosal.

After renewed examinations of this region in the fossil and comparisons of it with specimens of *Bison bison* the author fails to find any way of reconciling the differences.

The bar of bone between the foramen lacerum medius and the foramen lacerum anterius is thin, 3 mm., and in front has an acute edge. In the other two bovines here considered the bone is considerably thicker (from 7 mm. to 11 mm. in the bison) and the front edge is obtuse.

The parocipital process is broken off, as is also the bulla.

The squamosal of our fossil, seen from the outside, presents some features and relations of interest. In both the living bison and in the jersey that part of the squamosal which enters into the temporal fossa rises perpendicularly or in the jersey even slopes inward to join the parietal. In the fossil bison the bone as it ascends turns outward, so as to overhang very considerably. Just above the root of the zygomatic process of the squamosal, at the rear of a considerable excavation, are two considerable venous foramina. These are present in the jersey skull also, and in many skulls of *Bison bison*, but their presence, number, size, and positions are subject to great variations.

The articular surfaces for the lower jaw are placed on a higher level with respect to the basisphenoid than in *Bison bison*. A line drawn from the lowest part of one of these surfaces to that of the other passes considerably above the basisphenoid. In the existing bisons examined such a line passes through the body of the basisphenoid. The same statement may be made regarding the jersey cow.

In the fossil bison here described the exoccipital of the left side is preserved nearly to the midline above the occipital foramen, where it met the one of the opposite side. This permits the measurement of the foramen. The distance from the front of the lower border of the foramen to the middle of the upper border is 40 mm.; in the jersey it is 38 mm.; in the skull of the small cow buffalo this measurement is 40 mm., as well as in a much larger male individual. In the fossil the greatest distance across the foramen magnum, just in front of the hinder borders of the condyles, was close to 50 mm.; in the jersey it is 45 mm.; in the skull of a large male bison, close to 50 mm.; in the skull of another large male bison, 45 mm.; in the cow buffalo mentioned, 44 mm. It will be seen that in the fossil the opening is absolutely larger than in the other animals used for comparison, although they belong to specimens of evidently greater size.

The cavity found just outside of each occipital condyle and into the front of which opens the condylar foramen is much shallower than in the great majority of specimens of *Bison bison;* but inasmuch as variations are observed in the latter one can not count with certainty on this shallowness as a specific character. Careful measurements indicate that the inner walls of the temporal fossae approached each other more rapidly from the rear to the front in the fossil than in the existing bisons, and that consequently the brain cavity of the former was actually and relatively narrower in front than in the latter. As exactly as can be determined the width of the brain-case of *B. sylvestris*, taken in the temporal fossa, over the auditory meatus, was at least 110 mm.; at the front of the glenoid articulation, not more than 90 mm. In the cow bison, already several times mentioned, the width at the rear position is 120 mm.; at the anterior position, 110 mm. In the jersey cow referred to above the measurements are respectively 98 mm. and 82 mm. Therefore the brain-case of *B. sylvestris* was narrowed forward almost exactly as in the jersey cow and more rapidly than in the existing bisons.

As nearly as the width of the skull can be determined it measured 180 mm. across the zygomatic arches at the glenoid fossae. In the case of the cow bison this measurement is 200 mm.; in the jersey cow, 166 mm. From the rear of one temporal fossa to that of the other is about 140 mm.

In the existing bison of our country the skull, at the narrowest place between the horns and the orbits, is at least as wide as it is across the zygomatic arches, often much wider. In the jersey cow the least width across the forehead is considerably less than across the zygomatic arches; and this appears to have been the condition in the extinct species here described. As just mentioned, the width across the glenoid fossae is 180 mm.; the least width across the forehead seems to have been close to 140 mm. The forehead naturally presented an appearance quite different from that of *Bison bison.*

So far as can be determined from the materials at hand, the parieto-occipital suture on the upper surface of the skull was pushed backward somewhat farther than in the American bison. In front of the pedestal of the horn-core there is a sharp crest which separated the temporal fossa from the forehead. In the existing bison this region is thick and obtuse. It is more acute in the jersey skull, but not so acute as in the fossil.

An apparent difference between the existing species of bison and the fossil here described is found in the occipital condyles. In the fossil the condyle is narrow near its lower anterior end; the least width from its border at the foramen magnum to that near the excavation containing the condylar foramen is about 21 mm.; in the specimens of *Bison bison* examined the width varies from 26 mm. to 33 mm. Naturally other specimens of *B. sylvestris* might abolish this difference.

The lower jaw is represented by the greater part of the horizontal ramus of the right side. Only the hindermost part of the symphysis is left, the bone being broken off just at the front of the mental foramen. On the outer side the bone as preserved continues backward above and below to points a short distance behind the socket of the hindermost molar; on the inner side to a line descending from a point just behind the second true molar. In this jaw are retained the last premolar and the first and second molars. The sockets of the second and third premolars and the last molar are present.

It is, of course, impossible to determine what was the length of the jaw and the length of its symphysis. The following measurements are obtained and compared with corresponding measurements of the jaw of the jersey cow already mentioned and of two female specimens of *Bison bison* (No. 14099, Amer. Mus., and No. 49680, Nat. Mus.). In the case of the jersey the front milk molar must take the place of the second premolar in the measurements.

Measurements of lower jaws in millimeters.

	Bison sylvestris.	*B. bison*, 49680, U.S.N.M.	*B. bison*, 14099, Amer. Mus.	Jersey cow.
Distance from rear of symphysis to front of socket of the second premolar	62	70	56	50
Distance from rear of symphysis to rear of second molar	160	180	150	154
Distance from rear of mental foramen to rear of second molar	159	171	....	158
Height of jaw just behind the symphysis	23	36	24	26
Thickness of jaw just behind the symphysis	13	15	14	14.5
Height of jaw at front of socket of premolar $_2$	29	41	31	31
Thickness of jaw at front of socket of premolar $_2$	16	16.5	17	16
Height of jaw at rear of second molar	53	61	54	58
Thickness of jaw at rear of second molar	28	27	28	24

The following measurements of the lower teeth have been secured from the type-specimen of *Bison sylvestris;* from No. 14099, a female bison in the American Museum; an old domestic cow, No. 92, in the collection of Mr. S. H. Chubb, of the American Museum; and the already oft-referred-to jersey cow in the United States National Museum. The teeth of No. 92 had been more worn down than in the other specimens, and this fact will account for the reduced length of the grinding faces.

Measurements of lower teeth in millimeters.

	Bison sylvestris.	*B. bison*, No. 14099.	Old cow, No. 92.	Jersey cow.
Distance from front of socket of pm $_2$ to rear of socket of m $_2$	104	95	93	104
Distance from front of pm $_4$ to rear of m $_2$	71	66	85	72
Premolar$_4$, height	19	22	16	....
Premolar$_4$, length	21	20	18	....
Premolar$_4$, width	12	11.3	15	....
Molar$_1$, height	20	25	15	30
Molar$_1$, length	22	23	22	24
Molar$_1$, width	13.5	14.5	13.5	13
Molar$_2$, height	34	30	23	46
Molar$_2$, length	26	24	23	26
Molar$_2$, width	17	15	14	16

The second and third premolars of the jersey had not been cut, and the first two measurements of the third column start with the front of the corresponding milk molar. In the case of the second molar of *Bison bison* (No. 14099, Amer. Mus. Nat. Hist.) the height and the greatest width can not be determined without cutting into the bone. The heights of the teeth are given in order to indicate approximately the amount of wear. As the teeth are worn down the fore-and-aft length of the crown diminishes, while the width increases. It is to be noted that the teeth of the jersey cow are less worn down than either of the others. Were we to measure the length of the crown of the jersey at the same level as those of the fossil, the former would show a length at least a millimeter less than they do. Where possible, the width of the teeth as given is that at the base, where greatest.

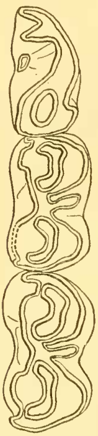

Fig. 1.—Lower molars of Bison sylvestris. × 1.

It is necessary now to compare the teeth of the fossil with those of the jersey and of the bison. The teeth of the fossil (pl. 30, figs. 3, 4; text-fig. 1) are somewhat injured, but not to a serious extent. A little enamel is split off from the outer and the inner styles at the rear of the fourth premolars. A part of the hinder inner column (entoconid) is broken away, also a very little of the summit of the anterior outer column (protoconid) of the second molars; likewise a sliver from the hinder inner style of the same tooth. All of the cement has been dissolved off the teeth and the dentine is considerably decayed. The enamel of the teeth is apparently more wrinkled than in most specimens of the two species with which it is here compared.

In the fourth premolar the excavation, or infold, in the outer face, in front of the hinder style, is much narrower and more sharply defined than in the specimens of *B. bison* examined. In the existing bison there are usually two infoldings of the enamel of the hinder half of the inner face of the tooth and in front of these a narrower excavation or channel. Sometimes the hinder infold is divided so as to cut off a circular pit in the hinder part of the tooth. The anterior infold referred to is usually directed inward and often inward and backward. In the fourth premolar of *B. sylvestris* there is a circular pit in the hinder part of the tooth, as seen in the figure. The enamel of the inner face is directed forward and outward to near the point of the tooth, then abruptly inward, then again outward and forward, and finally again inward. There is thus formed a great excavation in the inner face of the tooth, and in front of this two folds of the enamel. At the bottom of the excavation there arose a slender accessory column, but this is broken off. This tooth in *B. bison* presents a considerable amount of variation, and it is possible that it sometimes takes the form seen here in *B. sylvestris.*

The two molars resemble closely the corresponding teeth of *B. bison.* The inner columns are somewhat more sharply separated by shallow folds of the enamel from the body of the tooth, but probably similar conditions might now and then be found in specimens of *B. bison.* One can not yet say that there is any character in the teeth of *B. sylvestris* by which it may be distinguished with certainty from *B. bison;* but it is also true that the teeth of all the bisons are much alike and all resemble closely those of the domestic ox.

It will be seen that the animal whose scanty remains were secured in Ohio does not belong to the genus *Bos;* it is equally evident that it did not belong to any species of bison hitherto found in this country. To judge from the parts known, the type-specimen had the size of a small domestic cow; but it is probable that the males were considerably larger. The skull seems to have been somewhat wider, but to have had the same length. The horns were feeble, but doubtless larger in the males. As to the habits of this bison, we can infer little. There can be no doubt that, like the megalonyx which found a grave in the same spot, it lived after the passing away of the Wisconsin ice sheet. The presence of the megalonyx seems to imply the existence of a climate warmer than that of to-day. At the same time in all probability there lived in that region mastodons, elephants, peccaries, and the giant beaver, all, like the bison, now gone. Doubtless then, as now, Ohio was heavily forested. In these forests, possibly haunting the swamps, lived the animal that is to be known as *Bison sylvestris.*

BOÖTHERIUM NIVICOLENS, new species.

Diagnosis.—A Pleistocene species of *Boötherium* which has the exostoses of the horn-cores slightly encroaching on the forehead; horn cores directed strongly outward, only slightly downward and forward.

Type.—Both horn-cores with the frontals. Found at Elephant Point, Alaska.

An incomplete skull of a species of musk ox, No. 2324 in the United States National Museum, was collected in 1880 on the shores of Eschscholtz Bay, Alaska, probably at Elephant Point, by Capt. C. L. Hooper, commanding U. S. revenue steamer *Corwin.* The specimen has hitherto been regarded as the skull of a female of *Ovibos moschatus*, but a close examination shows that this is an error.

In his report of the cruise of the steamer *Corwin*, published in 1881, on page 24, Hooper wrote as follows in speaking of his visit to Elephant Point:

I searched the face of the cliff at Elephant Point for fossil remains, but found none either in the ice or in the soil above it. I was more fortunate, however, on the beach below after the tide fell. There I found a large number of mammoth bones and tusks and some smaller bones belonging, probably, to the "aurock" and musk ox.

Although the skull here described was not specifically mentioned, it is probable that it was included in among the "smaller bones."

The specimen (pl. 31, fig. 1) consists of the horn-cores practically complete and the parietal and frontal bones which bore them. The supraoccipital region is missing, also the whole of the floor of the brain case and the bones of the jaws. Of the orbits, only the upper and hinder part of the rim of the left one is preserved. The frontals do not extend as far forward as the notch for the hinder ends of the nasals. Many important measurements are therefore not to be obtained. The following are given:

Measurements of the skull of Boötherium nivicolens in millimeters.

Width at notch between orbits and horn-cores at the lower border of the latter	126
Width at the rear of the orbits, estimated	185
Least distance between exostoses of horn-cores on forehead	100
Distance between exostoses at rear of horn-cores	140
Transverse diameter of brain case	90
Thickness of parietal bone at about its center	46
Fore and aft diameter of base of horn-core	63
Vertical diameter of base of horn-core	58
Circumference of base of horn-core	200
Length of horn-core on hinder curve	205
Length of chord of anterior curve of horn-core	165
Distance between the extremities of the horn-cores	466

The rear of the upper surface of the specimen extends backward a distance of 75 mm. behind the line which joins the hinder borders of the bases of the horn-cores, and it must have reached the occipital crest. The hinder end of the skull, at the level of the parieto-squamosal suture must have had a width of close to 105 mm. In getting the width of the skull between the orbits and the base of the horn-cores in *Ovibos* one measures at the middle of the height of the horn-core or even higher. In the specimen of *B. nivicolens* it is necessary to descend to the lowest point of the base of the core, for from this point upward the skull narrows.

The base of the horn-core is nearly circular in section, the upper surface being only slightly flattened. At about the middle of the length the horn-core is still flattened, the fore-and-aft diameter being

48 mm., the vertical 41 mm. The horn-cores descend less as they pass outward than they do in either *B. bombifrons* or *B. sargenti.* When a cord is stretched from the tip of one horn-core to that of the other it passes but little in front of the rear of the orbit and above what would evidently have been the lower border of this. The cord is on a level with the roof of the brain cavity.

The horn-cores may be said to stand on short pedicels and to have a burr, as in the bisons. On the upper surface, however, the exostosis has just begun to spread on the forehead and has hidden the pedicel. The condition is intermediate between that seen in *B. bombifrons*, with an evident pedicel, and that of *B. sargenti*, in which the exostosis has advanced well on the forehead.

The parietal bone is a mass which contains numerous small cavities, like those of a fine sponge. The frontals, 60 mm. thick at the midline, are occupied by large air cells, some of which open into the bases of the horn-cores. The plane of that part of the upper surface of the skull which is behind the horn-cores makes an angle of about 47° with the plane of the anterior part. The angle in *B. sargenti* appears to be about the same as in *B. nivicolens.* Considering all the facts, the writer is compelled to place both these species just mentioned in the genus *Boötherium.*

Because of the direction taken by the horns, more outward and less downward, *B. nivicolens* is evidently distinct from both the other species. By its long slender horn-cores, carried far in advance of the orbits, *B. sargenti* is distinguished from *B. bombifrons.*

BOÖTHERIUM SARGENTI Gidley.

This species was described by J. W. Gidley in 1908.[1] The describer's figures present views of the partial skull as seen from in front, from the left side, and from above. His description is brief, and no measurements were presented. Neither are the relative sizes of the figures given; but the statement was made that the size was about two-thirds that of *Ovibus moschatus* and somewhat greater than that of *Boötherium bombifrons.* Wishing to study the specimen at first hand the present writer, in January of the year 1914, visited the Kent Scientific Museum at Grand Rapids, Michigan, where the specimen is deposited. Opportunity to examine this and other Pleistocene materials was freely given by the director of the museum, Mr. H. E. Sargent.

The specimen was found, as stated in the original description, in the Moorland swamp, on the farm of Mr. Charles McKay, near Grand Rapids, Michigan. Mr. McKay has kindly informed the writer that the exact locality is in the northwest quarter of the northeast quarter of section 16, in township 10 north, range 14 west.

[1] Proc. U. S. Nat. Mus., vol. 34, p. 683, pl. 79.

This is very nearly 25 miles from Grand Rapids in a straight line in a direction a little north of northwest. The depth at which the skull was found was about 2 or 3 feet only. Mr. Sargent informed the writer that the skull lay beneath the pelvis of a mastodon, the nearly complete skeleton of which is mounted in the Kent Scientific Museum.

The following measurements were secured from the skull. Inasmuch as it is much damaged in its axial portions many desirable measurements, especially the basilar length, could not be obtained. A figure is shown (pl. 31, fig. 2) which gives a view of the skull from the left side. Mr. Gidley published a figure from the same photograph.

Measurements of skull of Boötherium sargenti in millimeters.

Distance from the rear of one orbit to that of the other	190
Width of skull between the orbits and the horn-cores, on a level with the lower surface of the latter	128
Width of space between the horn-cores at their rear	147
Width of space between the horn-cores, on the face, least	62
Fore-and-aft diameter of the orbit	65±
Length of a horn-core along the hinder curve	352
Circumference of the base of a horn-core	242
Fore-and-aft diameter of a horn-core	80
Diameter of horn-core at right angles to preceding	68
Distance between tips of horn-cores, direct	505
Width of brain cavity	88

The distance from the occipital crest to the notch for the rear end of the nasals was close to 210 mm.; the crest itself is missing. In *Boötherium bombifrons* this distance is 240 mm.

The horn-cores (pl. 31, fig. 2) are directed strongly outward and forward and somewhat downward. The distal extremity of each reaches a point 55 mm. in front of the rear of the nasals and 95 mm. below the upper surface of these bones. At the base the horn-core is subcircular in section; but the upper face is considerably flattened. However, at a short distance from the base the section becomes nearly circular. The surfaces of the cores are strongly grooved. A fragment of each of the nasals about 70 mm. long is present and to each is attached a fragment of the maxilla.

The profile of this skull is not straight. It is convex in the region of the horn-cores and concave between the orbits.

Dr. J. A. Allen[1] has expressed the opinion that this skull represents merely the female of *Symbos cavifrons* and that it shares no essential features with *Boötherium bombifrons*. He says that the horn-cores are attached to the skull as in the female of *Ovibos*, with about the same relative area of exostosis extending from the base over the

[1] Mem. Amer. Mus. Nat. Hist., vol. 1, pp. 214, 215.

lateral third or more of the frontals and not, as in *Boötherium*, supported on a pedicel and terminating in a burr as in *Bison.*

That the type of *Boötherium sargenti* is the female of *Symbos cavifrons* the present writer does not, for various reasons, at all believe. He has examined about 25 skulls which belong to *Symbos cavifrons.* In all of these the exostoses of the horn-core meet across the forehead. If the Grand Rapids skull is the female of *S. cavifrons*, it is very remarkable that only one female should be discovered among 25 specimens. Among the skulls of *S. cavifrons* there is a good deal of variation in the size of the cores. It seems very probable that those specimens which have the more feebly developed cores are the females. Inasmuch as in the males of *Symbos* the exostoses are more strongly developed than in the males of *Ovibos*, one might expect them to be more strongly developed in the females of *Symbos* than they are in those of *Ovibos.* These exostoses having reached the limit in the males, had probably reached that limit in the females likewise. The horn-cores of *B. sargenti* are, relatively to the size of the animal, longer than they are in *S. cavifrons;* and, besides, they are directed more strongly outward and farther in front of the orbit. Notwithstanding the immense development of the horn-cores of the males of *Symbos cavifrons*, there is no such elevation of the region behind the orbits as we see in the case of *B. sargenti.*

On page 210 of his work on musk-oxen, Allen gives as one of the characteristics features of the genus *Boötherium* the abrupt downward slope of the dorsal outline of the skull posterior to the horn-cores. The type skull of *B. sargenti* has a slope of the same region which lacks but a few degrees of being equal to that found in *Boötherium.* The other characters mentioned by Allen as distinguishing *Boötherium*, the form of the basisphenoid and the presence or absence of lachrymal fossae can not be determined in the skull of *B. sargenti.* In size the animal was somewhat below *B. bombifrons.* As to the fact that the bases of the horn-cores had begun to spread across the forehead, it may be said that it becomes simply a question whether we shall put the specimen in the genus *Boötherium* or establish a new one for it. Inasmuch as *Boötherium nivicolens* is intermediate, with respect to the extension of the exostoses, between *Boötherium bombifrons* and *B. sargenti*, the writer prefers to retain the latter in *Boötherium.*

2. DESCRIPTIONS OF THE NEW HORSES.

EQUUS HATCHERI, new species.

Diagnosis.—A large Pleistocene horse, which resembles closely the larger varieties of *Equus caballus*, but which has a broader skull, a heavier lower jaw, and certain differences in the teeth.

Type.—A nearly complete skull and lower jaw. Found near Hay Springs, Nebraska.

In the United States National Museum is a nearly complete skull which belongs to a species of *Equus*, which was found in 1886 in the region south of Hay Springs, Nebraska, and which has the number 7868. The exact locality is given on page 568, where is indicated the place at which certain limb bones of horses had been discovered. All these remains were collected by Mr. Hatcher and his party.

Certain fragments of bone are missing from the skull, as seen from above and from the sides; other parts are gone on each side of the base of the skull and from the palate. The illustrations (pls. 32, 33), prepared from photographs, indicate the positions of the missing parts. Apparently nothing is missing that is necessary to an understanding of the structure of the skull. The teeth are all present in both the upper and the lower jaws; the incisor teeth are worn down nearly to the bottom of the cups, but the premolars and molars show less wear. The second molar has still a height of 65 mm. Inasmuch as large canine teeth above and below are present, it is concluded that the animal was a male.

The following measurements have been secured from the skull. In order to permit comparisons to be made there are presented likewise, in parallel columns, corresponding measurements obtained from the skull of *Equus niobrarensis*, found in the same quarry and described in 1913,[1] and from a skull of domestic horse (No. 843, Nat. Museum). The dimensions within parentheses are taken from the lower jaw of a slightly smaller and older horse (No. 174968 Nat. Museum).

Measurements of skulls in millimeters.

Distances.	*E. hatcheri.*	*E. niobrarensis.*	*E. caballus.*
From middle of incisive border to front of foramen magnum	552	530	550
From middle of incisive border to front of posterior nares	300	290	300
From middle of incisive border to rear of notch between nasal and premaxilla	206	200	196
From middle of incisive border to rear of occipital crest	615	582	602
From middle of incisive border to front of pm_2	152	137	143
From middle of incisive border to front of orbit	364	340	362
From middle of incisive border to rear of orbit	427	420	438
Width across mastoid processes	114	110	129
Width across hinder nares	56	47	55
Width across articulations for lower jaw	230	217	213
Width from outside to outside of last molars	130	123	127
Width from outside to outside of outer incisors	76	78	75
Distance between fronts of orbits	176	158	153
Distance between rears of orbits	236	240	220
From middle of occipital crest to rear of orbit	228	218	228
Width of skull on maxillary ridge at maxillo-malar suture	210	187	188
Width of palate at last molars	82	70	77
Width of palate at pm^2	48	50	53
Distance across premaxillae at middle of nasal opening	72	75	67
Least width of palate between i^3 and pm^2	40	45	45
Distance between i^3 and pm^2	115	105	110
Diameter of orbit, fore and aft	68	84	70
From front of lower jaw to rear of ascending ramus	460	467	(472)
Length of symphysis of lower jaw	90	90	(97)
Height of jaw at front of m_1	100	96	(82)
Rear of i_3 to front of pm_2	102	93	(113)

[1] Proc. U. S. Nat. Mus., vol. 44, p. 576, pl. 69, figs. 3–4; pl. 70; pl. 71, figs. 1, 2; text figs. 19–23.

On comparing the above measurements it is seen that the horse here called *Equus hatcheri* had a longer skull than that of *E. niobrarensis*, one of the same length as that of the larger domestic horses. In Nehring's list of 60 specimens of equines measured there are only 7 which had longer skulls than that here described. It belongs, then, among the very large horses.

The width of the skull at the rear of the orbits is 236 mm. This does not appear to have been exaggerated in repairing the specimen. This width is equal to 42.6 per cent of the basilar length, so that this quantity represents the cephalic index. Nehring obtains this index in the reverse way, following which the cephalic index would be 234.9. This horse would then fall into Nehring's group of broad-faced horses, but, in Tscherski's classification, in the group with faces of medium breadth. As will be seen by referring to a table on a more advanced page, the skull of *E. hatcheri* has nearly the same cephalic index as the Przevalsky horse. The latter is, however, a smaller animal. *E. niobrarensis*, as indicated by the type, had a relatively broader skull, the index being 45.3; or, after Nehring's method, 220.8. It belongs, then, among those with the very broadest faces, resembling in this respect the kiang. Whether or not additional specimens of both *E. hatcheri* and *E. niobrarensis* would sustain our conclusions only future investigations will decide.

The cranial length is 195 mm.; that is, the distance from the middle of the occipital crest to the middle of the line joining the rear of the orbits. The cranio-cephalic index is determined, then, to be equal to 35.3, being, therefore, more nearly equal to that of the broad-faced domestic horses than to that of the narrow-faced ones. In *E. niobrarensis* the index is 34.3.

The facial length (distance from incisive border to the middle of the line joining the rear of the orbits) is 413 mm. This multiplied by 100 and divided by the basilar length gives as the facio-cephalic index 74.8. That of the type of *E. niobrarensis* has been determined to be 75.3. The horse which is here described is therefore relatively short-faced, as well as broad-faced.

The length of the nose is relatively greater than in the domestic horse No. 843, but nearly the same as in the type of *E. niobrarensis.*

There appears to be a considerable difference between the horse here described and the type of *E. niobrarensis* in the width of the face on the maxillary ridge. There is a possibility of some distortion in the specimens, but the differences appear to have existed in life. In *E. hatcheri* this width equals 38 per cent of the basilar length; in *E. niobrarensis*, 35.3 per cent; in the *E. caballus* measured only 34.2 per cent.

Attention may be called to the straightness of the outline of the skull, from the vertex to the front of the nasals (pl. 32). This profile is quite different from that of *E. niobrarensis*, and its form does not appear to be due to any distortion produced in restoring the skull.

The position of the hinder border of the vomer on the midline with reference to the lower lip of the foramen magnum and to the hinder border of the hard palate furnishes a character by means of which certain equids may be distinguished from others. On this matter the readers may consult tables given on succeeding pages. On account of injuries done in this region in the types of both *E. hatcheri* and *E. niobrarensis* the position of the vomerine notch can not be directly determined. Tests made on several skulls show that the distances of this notch from the two points mentioned are roughly proportioned to the distances from these two points to a small foramen situated just a little above and a little in front of the optic foramen. Estimates based on this assumption leave no doubt that the vomerine notch of *E. hatcheri* was somewhat nearer the palate than to the foramen magnum, and that it was considerably nearer the palate in *E. niobrarensis*, perhaps 25 mm. nearer. In a skull from Alaska described by the writer [1] and called *Equus niobrarensis alaskae* the distance from the vomerine notch to the foramen magnum is 121 mm.; that from the notch to the hard palate is 114 mm. This character may enable us to distinguish the Californian *E. occidentalis* from both *E. niobrarensis* and *E. hatcheri*. A skull of the western species described by Merriam [2] was sent to the American Museum of Natural History, where it has been examined by the writer. The distance from the foramen magnum to the vomerine notch is 122 mm.; from the notch to the hard palate, 141 mm. Merriam's figure of this skull [3] shows the position of the notch. However, from information furnished by Merriam it appears that the vomerine notch is sometimes nearer the hard palate than the foramen magnum.

Measurements are here presented of the teeth, both upper and lower. For comparison corresponding measurements are furnished of the teeth of the type of *Equus niobrarensis* and those of the domestic horse. The upper teeth of the latter species are those of No. 843 of the National Museum, while the lower ones are those of No. 174960 of the National Museum, a very large horse with basilar length of 610 mm., whose upper tooth line is, however, only 1 or 2 millimeters longer than that of No. 843.

[1] Smiths. Misc. Coll., vol. 61, No. 2.

[2] Univ. Calif. Pubs., Geol., vol. 7, No. 21.

[3] Idem, p. 399, fig. 3.

Measurements of teeth in millimeters.

Teeth.	Upper.			Lower.		
	E. hatcheri.	*E. niobrarensis.*	*E. caballus.*	*E. hatcheri.*	*E. niobrarensis.*	*E. caballus.*
Length molar-premolar series	187	179	185	188	180	187
Length premolar series	96	98	98.5	98	94	97
Length molar series	92	81	86	91	84	90
Pm2, length	40	38	40	40	35	36
width	28	27	27	16	15	16
protocone	11	10	10			
Pm3, length	30.5	30	30	30	28	30
width	31	28	29	18	16	17.5
protocone	15	13.5	14			
Pm4, length	30	29	29	30	30	30
width	30	27	30	17	16	17
protocone	14.5	14	15			
M1, length	28.5	17	27	29	27.5	27
width	29	28	29	18	14	15.5
protocone	14	13	15			
M2, length	27.5	27	28	28.5	27	28
width	27	25	28	16	13.5	15.5
protocone	14	14	16			
M3, length	30	26	31	35	30	34
width	24	23	25	15	13	14
protocone	15	14	16.5			
I1, diameter, side to side	15	19	16	14	17	16
diameter, fore and aft	13.5	13	11.5	11.5	11	11
I2, diameter, side to side	17.5	20	18	15	17	19
diameter, fore and aft	14	12	11	11	11	11
I3, diameter, side to side	18	21	20	12.5	17	17
diameter, fore and aft	14	11	11	13	11	13

When the upper grinding teeth of *E. hatcheri* (pl. 34, fig. 1; text-fig. 2) are compared with those of *E. niobrarensis* it is seen that they are in all cases longer, sometimes only slightly so, but in other cases 2 mm. or even 4 mm. longer. In width the differences are still greater. The lower teeth (pl. 33, fig. 2; text-fig. 3) are in all cases, except that of the hindermost premolar, greater in length than those of the type of *E. niobrarensis*, while, as in the upper teeth, the differences in the width are still greater. These differences must be taken into account in estimating the relationships of the two skulls. The differences in the lengths of the various cheek teeth, upper and lower, as compared with those of *E. niobrarensis*, would have been still greater if those of *E. hatcheri* had been measured at an earlier stage of wear. The differences among the dimensions of the corresponding incisors of the two species, certainly to a great extent, are due to greater wear in those of *E. hatcheri.*

It is proposed now to make careful comparison between the structure of the teeth of the fossil horse here described and that of the teeth of various specimens of the larger domestic horses; furthermore, to include in the comparisons the teeth of *Equus niobrarensis.* It is probable that not all of the differences observed among these horses will prove to be of specific importance, but it seems to be proper to note them in order that the important character may in due time be discovered.

It is observed that the outer styles of the upper teeth of *E. hatcheri*, both premolars and molars, are more strongly developed than in the domestic horses. In the third premolar, for example, the anterior style has a width of 8 mm., while in No. 843, referred to already, the width is only 5.5 mm.; in *E. niobrarensis* 6 mm. The median style of this premolar in *E. hatcheri* is 8 mm. wide; in No. 843, 7 mm.; in *E. niobrarensis* 5 mm. In the second molar of *E. hatcheri* the anterior style is 6.5 wide; the median style, 5.2 mm. In No. 843 the corresponding anterior style is 4 mm. wide; the median style, 5.5 mm.; therefore slightly larger than in *E. hatcheri*. In *E. niobrarensis*

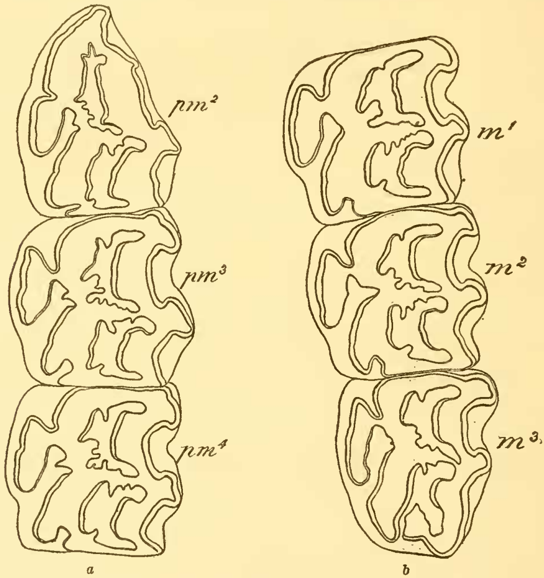

FIG. 2.—UPPER PREMOLARS (*a*) AND UPPER MOLARS (*b*) OF EQUUS HATCHERI. × $\frac{4}{10}$.

the anterior style is 4 mm. wide; the median 4 mm. The anterior style in the premolars of the domestic horse are usually flattened, and a slight groove runs along the face from base to summit of the tooth. In *E. hatcheri* the outer face of the style is convex and a very shallow groove is seen near the front edge of the face, while the median style on the premolars shows only a trace of a groove; in the molars no indication of it.

In *E. hatcheri* the hinder border of the anterior style, especially of the third and fourth premolars, is turned strongly backward, so as to overhang conspicuously the valley which descends between the anterior and the median styles. This feature is seen likewise in the molars, but not so strongly expressed. In the domestic horses observed the hinder border of the anterior style is not at all or only slightly rolled backward. In the Arabian horse skull (No. 172454, National Museum) the border turns rather strongly backward. In the type of *E. niobrarensis* it is not at all rolled backward. Probably in each species there is in this character a good deal of individual variation.

In all the cheek-teeth of *E. hatcheri* the inner face of the protocone is distinctly convex, whereas in the type of *E. niobrarensis* this face

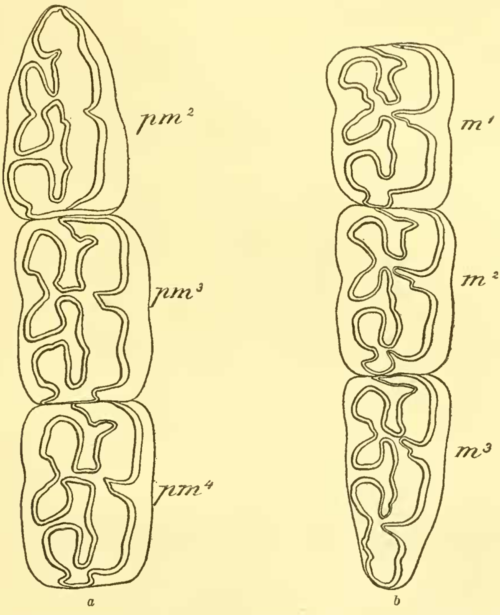

FIG. 3.—LOWER PREMOLARS (*a*) AND LOWER MOLARS (*b*) OF EQUUS HATCHERI. $\times\frac{8}{10}$.

of the protocone is divided by a distinct groove into an anterior lobe and a larger posterior one. In the domestic horses the inner face of the protocone is usually, but not always, either flat or somewhat concave.

As regards the plication of the enamel which surrounds the lakes in the upper molars, it may be said that no essential differences have been observed on comparison with the cheek teeth of the domestic horses. In the type of *E. hatcheri* the plication is less developed than in some domestic horses, more so than in others. Opposite the head of the anterior inner valley, at the hinder inner angle of the anterior lake of *E. hatcheri*, there is in the molars, but more conspicuously in the premolars, a reëntering double fold, resembling somewhat an M. The homologue of this is usually present in the domestic horses, but is rarely so broad, and it is often only a simple fold.

Wilckens[1] concluded that the complication of the enamel surrounding the lakes of the upper cheek-teeth is far simpler in the Arabian horse than in what he called the occidental horses. His figures (pl. 9, fig. 5) represents the lakes as surrounded by enamel with little crinkling in the adjacent borders. In the Davenport Arabian horse the enamel of the lakes is more complicated than it is in many of the large domestic horses.

The anterior inner valley of the upper cheek-teeth of *E. hatcheri* is directed less outward than in the corresponding teeth of *E. caballus;* and, especially in the premolars, does not reach so near the center of the tooth as it does in the domestic horses.

The reëntering fold in the head of the anterior inner valley, so commonly seen and so deep in the premolars of the large domestic horses, is shallow in the premolars of *E. hatcheri* and absent in the molars, except in the last one, where it is a mere nick.

In the lower cheek-teeth of *E. hatcheri* the valley (pl. 34, fig. 2) seen at the middle of the outer face is shallower than in the greater number of domestic horses. In the premolars of the latter it reaches usually more than half way to the enamel of the inner face, while in the premolars of *E. hatcheri* it does not penetrate the tooth so deeply. In the molars of most specimens of *E. caballus* this valley forces itself between the longitudinal expansions of the two inner valleys and almost reaches the enamel of the inner face. In *E. hatcheri* the outer valley does not get in between the longitudinal expansions mentioned. The writer has seen relatively few specimens of the domestic horse in which the outer valley fails to push in between the longitudinal valleys of the molars, and a specimen is found now and then in which the condition is found in the premolars which prevails in the molars.

In *E. caballus* the outer valley of the lower cheek-teeth has, in both premolars and molars, a distinct reëntering fold in its hinder border. In *E. hatcheri* this fold is absent or small in the premolars and small in the molars.

In the upper cheek-teeth of *E. niobrarensis* the anterior inner valley sends forward and outward, behind the deep reëntering loop, a prolongation which reaches the center of the tooth. This great inner valley is quite different from that of *E. hatcheri*. In none of the teeth of *E. niobrarensis* is there found in the anterior lake a double M-like fold facing the head of the anterior inner valley. In

[1] Nova Acta. Acad. Caes. Leop. Car., vol. 52, p. 264.

the molars there is a single, rather deep reëntering fold; in the premolars, some small plications.

In the lower cheek-teeth of *E. niobrarensis* the valley which enters the tooth at the front of the inner face sends toward the outer face of the tooth a horn-like process which is narrower and longer than it is in *E. hatcheri* and the domestic horses. The wall which bounds outwardly the expansion of the hinder inner valley is much more strongly undulated than it is in *E. hatcheri*. To what extent these characters vary in different individuals of the two species must be left for determination to future research.

EQUUS FRANCISCI, new species.

Diagnosis.—A small Pleistocene horse which had apparently the size of *Equus tau* Owen, but which had the last premolar and the anterior two molars wider than long, instead of longer than wide. Enamel of cheek-teeth in simple pattern.

Type.—A nearly complete skull and considerable fragments of the skeleton. Found in Wharton County, Texas.

From Prof. Mark Francis, of the veterinary department of the Agricultural and Mechanical College of Texas, at College Station, the writer received a letter, dated May 27, 1913, in which an account was given of the discovery in that region of some remains of an extinct horse. The information communicated was that about February 1 a farmer living at or near a town by the name of Lissie, in the northern part of Wharton County, had, in digging a well, and at a depth of 25 feet, met with a skeleton of some animal. No effort was made to save the bones, but they were broken up with the pick and shovel and the fragments were thrown out on the dump. About ten days later Professor Francis learned of the discovery and went to the place to see what had been unearthed. He found the remains to be those of an extinct horse, and he secured most of the skull and many parts of the rest of the skeleton. The skull had been broken and some parts of it had been lost. It is quite probable that the complete skeleton was there and might with some efforts have been secured by the farmer.

The remains thus obtained were sent to Ward's Natural History Establishment, at Rochester, New York, for restoration. About April 1, 1914, they were sent to the writer for examination and description.

Professor Francis deserves credit for the zeal and intelligence which he has shown in saving this valuable specimen. He is continually watching for such discoveries, and as a result he has secured a large and valuable collection of the remains of many fossil vertebrates of his region. Furthermore, in doing so he has taken care to obtain all the possible information regarding the localities where they have been found and under what conditions.

The skull of this specimen is nearly complete (pls. 35, 36). A portion across the middle of the face is missing, and this has carried with it the right premolars. The molars of this side are present, as are the molars and the premolars of the left side. The first incisor of the right side is missing, the others are present. The lower jaw is present, but lacks the premolars of the left side and two of those of the right side. Attached to the skull was the atlas. Of the anterior limbs both radii are preserved, with little injury. Of the right hind leg there are present the patella, the tibia (lacking about the upper fourth), the astragalus, the calcaneum, the cuboid, and the third metatarsal, except some portions thereof. Of the left hind leg there are present a small part of the distal end of the tibia; all the bones of the ankle; the third metatarsal, excepting a part of the shaft; the proximal halves of the second and fourth metatarsal; and the first and second phalanges of the third digit. The hoof phalange is missing.

Besides these parts there is a considerable amount of fragments of limb bones, vertebrae, and the like, some of which will receive consideration.

All the bones are thoroughly fossilized. They were imbedded in a layer of sand and small gravel; and these materials were cemented together by calcium carbonate, thus forming a matrix which in places is hard and rather difficult to remove.

From a report published recently by Dr. Alexander Deussen of the United States Geological Survey,[1] it is learned that the deposits in question belong to the Lissie formation, named from the town above mentioned. This formation occupies a strip which runs across the State of Texas, parallel with the Gulf coast line, and having its southern border about 55 miles at the east from the coast. The strip has a width of about 25 miles wide in its western half. The formation consists mostly of gravels and conglomerates, in some places containing considerable limy materials. In the eastern part of the State there are red clays and ferruginous sands. It is believed that to this formation corresponds the middle of three terraces which are found along many of the large rivers of that State. It is supposed by Deussen that the materials of the Lissie formation were spread out at the mouths of the valleys of the streams which discharged into the sea during some parts of the Pleistocene, probably the early and middle parts.

The present writer is inclined to believe that the Lissie belongs to the early Pleistocene, corresponding, in part at least, to the Aftonian. From Hardin County was obtained *Equus complicatus*, associated with the saber-tooth tiger *Smilodon fatalis* and two extinct species of fresh-water tortoises. The great ground sloth *Megatherium* has

[1] U. S. Geological Survey, Water-supply Paper No. 335.

been found in two places along the Brazos River. In Nueces County, probably in the same formation, Cope reported *Equus* associated with a camel; and from the same region he described a *Glyptodon.* From Bee County there have been obtained remains of *Elephas imperator* and *Bison latifrons*, probably too *Bison regius.* From about San Diego have been described four species of extinct horses.

A study of the remains seems to show that this horse is more closely related to *Equus tau* Owen, than to any other yet described. Indeed it is possible that it belongs to that species, but there are certain features which appear to mark the animal as being more primitive than Owen's species, and it seems, therefore, better for the present to give it a distinct name. This shall be *Equus francisci*, in honor of the discoverer. For figures of the skull see plates 35, 36, and 37.

The following are the measurements of the skull. In the second column are the corresponding measurements of a specimen of *Equus hemionus*, which was collected by Dr. W. L. Abbott, on the Hanlé River, in Kashmir:

Measurements of skulls in millimeters.

	E. francisci.	*E. hemionus.*
From middle of incisive border to rear of occipital condyles	438	470
From middle of incisive border to front of foramen magnum	414	445
From middle of incisive border to rear of hard palate	210	222
From middle of incisive border to naso-premaxillary notch	133	153
From middle of incisive border to middle of occipital crest	460±	498
From middle of incisive border to front of pm ^{2}	110	108
From middle of incisive border to rear of orbit, direct	328	356
From middle of incisive border to front of orbit	270	291
From middle of incisive border to notch at rear of vomer	310	341
From middle of incisive border to middle of line joining rear of orbits (facial length)	316	340
Width across mastoid region	100	105
Width at glenoid fossae	167	198
Width from outside to outside of last molars	99	116
Width from outside to outside of last premolars	100	112
Width from outside to outside of canines, at base	50	61
Width from outside to outside of outer incisors, at base	68	69
Width of skull at the front of the orbits	130±	137
Width of the skull at the rear of the orbits	175±	203
Width of skull on maxillary ridge at maxillo-malar suture	152±	166
Width of palate at last molars	57	74
Width of palate at pm ^{2}	40±	45
Width of palate at diastema, least	39	46
Length of orbit	60	60
From front of symphysis of lower jaw to rear of ascending ramus	352	375
From front of symphysis to rear of condyle	380	405
Length of symphysis	54	72
Height of jaw at front of m $_1$	70	78
Elevation of condyle above lower border of jaw	195	215
From rear of third incisor to front of pm $_2$ (diastema)	72	76

In the above measurements of *E. francisci* certain dimensions can not be determined with absolute accuracy, as is indicated in the table. However, all of these, except perhaps the fifth, are so close to the true values that the deviations may be neglected. The occipital crest is broken away so badly that its border can not be determined exactly. Although a considerable section is missing from the skull in the region of the premolars, the connection of the snout with the premolar on the left side is such as to show very accurately the relation of the parts.

If now we multiply the width of the skull at the rear of the orbits, 175, by 100 and divide the result by the basilar length, 414, we obtain the cephalic index, 42.3. That of *Equus hemionus*, is 44.4, which is somewhat less than that of a specimen measured by Tscherski. On referring to the tables on pages 559 and 560, the reader will find that the Texan skull is intermediate in width between the narrow-faced horses and the broad-faced ponies.

The facial index (facial length $\times$ 100 $\div$ basilar length) of the Texas specimen is 76.1, that of *E. hemionus* 76.4. The face of both these animals is, as shown by the tables referred to, rather long. The length of the nose of the Texas specimen makes 27.3 per cent of the basilar length; in *E. hemionus* the corresponding index is 24.2. In the Arabian horse (No. 172454 Nat. Mus.) this index is 26.4. Hence the Texas horse had a relatively long nose. The tooth row is relatively very short, forming only 30.4 per cent of the basilar length; while in the specimen of *E. hemionus* it forms 34.1 per cent, and in the Arabian horse 34.5 per cent. In a very large horse skull in the National Museum (No. 174960), with a basilar length of 610 mm., the index of the tooth line is 30.6. The basioccipital bone of *E. francisci* is different from that of any of the other horses at hand. In all of them and in *E. hemionus* this bone, immediately in front of the articular surfaces of the condyles, slopes away gradually on each side. In the Texas horse the sides are nearly perpendicular. The thickness of the bone from side to side is 20 mm. The distance from the lower border of the foramen magnum to the notch on the hinder end of the vomer is 111 mm.; from the notch to the hinder border of the hard palate 100 mm. In this respect the skull of *E. francisci* agrees with the true horses and differs from the domestic ass and from *E. occidentalis* of California.[1] The hard palate ends in the midline opposite the middle of the length of m^2. The posterior palatine foramina are situated on the line joining the hinder ends of the second molars. There is no indication of any pit on the side of the face in front of the orbit.

The teeth (pl. 35; figs. 1, 2; text-figs. 4, 5) have furnished the following measurements. In the second column are expressed the measurements obtained from Owen's figure of *Equus tau;* in the third column the measurements of the teeth of *E. hemionus.*

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[1] See page 530.

Measurements of the upper teeth in millimeters.

	E. francisci.	*E. tau.*	*E. hemionus.*
Premolar-molar series, length	135	....	151
Premolar series, length	74	....	81
Molar series, length	61	65	70
Pm^2, height	55±	....	....
length	28	....	32
width	23	....	24
protocone	8	....	8
Pm^3, height	60	....	....
length	23	23	25.5
width	23	20	26
protocone	10	10.5	12
Pm^4, height	56	....	....
length	21	23	24.5
width	23	19	26
protocone	10.5	10	13
M^1, length	19.5	21	22.5
width	22	20	23
protocone	11	11	11.5
M^2, length	20	22	23
width	21	18.5	23
protocone	12	11.5	14
M^3, length	21	25	24
width	18	16	20.5
protocone	12	11	15

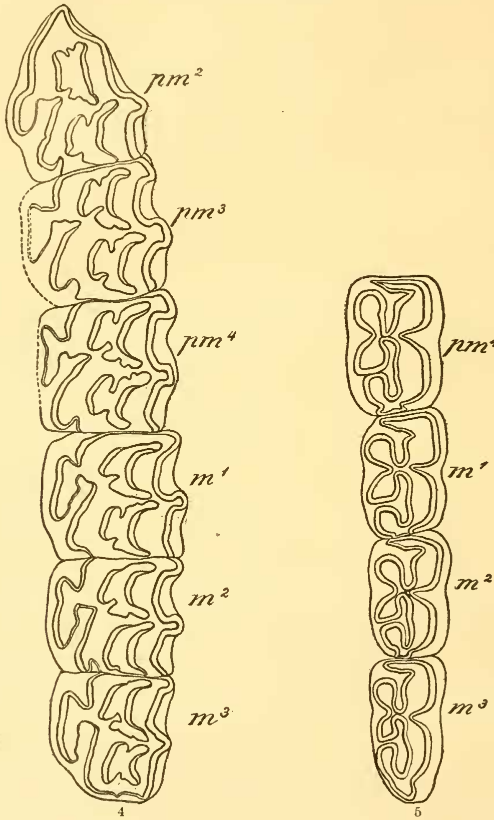
In the lower jaw there are present all the incisors, the three molars of both sides, and the last premolar of the right side (pl. 37, figs. 1, 2; text-fig. 5). The following measurements are obtained:

Measurements of the lower teeth in millimeters.

	E. francisci.	*E. hemionus.*
Length of the molar series	66	72
Pm_3, length of grinding face	22	23.5
width of grinding face	14.5	16
M_1, length of grinding face	20	21.5
width of grinding face	13	14
M_2, length of grinding face	20	22
width of grinding face	12.5	14.5
M_3, length of grinding face	24	29
width of grinding face	12	13
I_1, diameter from side to side on grinding surface	12.5	....
diameter from front to rear on grinding surface	7.5	....
I_2, diameter from side to side on grinding surface	12.5	....
diameter from front to rear on grinding surface	6	....
I_3, diameter from side to side on grinding surface	15	....
diameter from front to rear on grinding surface	5.5	....

Owen did not furnish any measurements of the upper teeth which formed the type of his species; but if we may depend on the measurements taken from his figure, as it appears probable that we may, certain differences between the two specimens appear at once. All of the teeth of Owen's type are considerably longer than wide. In *E. francisci*, if the anterior premolar and the hindermost molar are excepted, the teeth are as wide as long or wider than long. This difference is so great that it appears at once to stamp the two individuals as belonging to distinct species. A study of the teeth of the Texan specimen shows that the arrangement of the enamel forms a quite simple pattern, approaching in this respect some of the species of *Protohippus*.

In all the upper premolars and molars the styles descending on the outer face are strongly developed, those of the premolars being distinctly broader. The protocones (anterior internal columns) are



FIGS. 4–5.—4, UPPER PREMOLARS AND MOLARS. 5, LOWER LAST PREMOLAR AND MOLARS. SLIGHTLY LESS THAN NATURAL SIZE.

large, the length in the case of the molars being equal to one-half or more of the length of the grinding face of the tooth; and each extends well forward of its connection with the antero-median column (protoconule). The internal face of each column is nearly flat. The anterior internal valley is rather narrow and is furnished with no reëntering loop at its anterior end, except that in M_3 there is a very small loop. In the premolars this valley has its axis directed toward the front of the median style of the next tooth in front. In the molars it is directed still farther forward, to the anterior outer style of the next tooth in front or even to the rear of the second tooth in front. In all cases it lacks much of reaching to the center of the tooth. The fold of enamel which in the most of the horses extends forward between the postero-internal column (hypocone) and the postero-median column (metaconule) is small in the premolars, extremely small in the front two molars, and missing in the last molar. The small size of this fold constitutes an approach to *Protohippus.*

The walls of enamel surrounding the lakes of each tooth are little complicated; least so in the molars. In the premolars there is a small reëntering fold in both the front and the rear sides of both the lakes, with perhaps some additional undulations of the enamel. In the molars there is no infold in the front of the anterior lake and only a very small one in the hinder wall of the posterior lake. The hinder border of the anterior lake has a small infold opposite the head of the anterior internal valley. The front border of the posterior lake is slightly more complicated, there being an infold and two or three undulations in the enamel. In the first upper incisor the median longitudinal ridge is obsolete, so that the front of the tooth from side to side is concave. In the third incisor the ridges all appear to be obsolete. In the lower incisors the median groove is broad and shallow.

The writer proposes to describe with as much exactness as he can and as briefly as is consistent with this exactness such of the bones of the trunk as have been preserved.

In making these measurements the writer has consulted especially the paper of Nehring[1] and that of Tscherski[2] and has endeavored to make the measurements conform as far as possible with those of those authors; but the number of measurements is here reduced. It is thought well to make the following explanations. In measuring the bodies of the vertebrae the distance is taken between the point on the anterior articular surface farthest in front and the point farthest in front on their hinder articular surface, this being usually nearly from center to center. The other measurements of the vertebrae do not need explanation. The length of the scapula is taken from the front of the glenoid cavity, along the spine, to the line which separates the endosteal bone from that of the main part of the scapula.

In the case of the humerus the total length is the distance from the upper end of the ridge between the two bicipital grooves to the distal end. The length of the radius is measured on the outer border of

[1] Landwirthsch. Jahrb., vol. 13, 1884, p. 81.
[2] Mem. St. Petersb. Acad. Sci., ser. 7, vol. 40, pp. 257–383.

the bone from the middle of the outer edge of the articular surface for the humerus to the surface for union with the cuneiform bone, really the lower end of the ulna. This is one of Nehring's measurements, as understood by the present writer.

The median metacarpal is measured on the outer border from one articular surface to the other.

The first phalange is measured on the outer border, beginning above at the middle of the outer border of the upper articular concavity. The length of the second phalanx is obtained in the same way. In these cases we obtain the efficient length, but not the total length. The middle of the length of the femur is midway between the upper surface of the head of the bone and the internal condyle. The lengths of the median metatarsal and of the phalanges are obtained as in the fore foot.

There are present 12 presacral vertebrae; but most of these are more or less injured, and only a part of the desired measurements can be obtained. For comparison, the corresponding vertebrae of *E. hemionus* and of the Arabian horse are furnished. The atlas has lost a part of the right wing. The following are some of the dimensions of the bone, a part of them estimated, but they may be relied on.

Measurements of the atlas in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length of the upper arch at the midline	38	41	52
Width in front, across the anterior foramina	110	110	136
Width in the rear, across the hinder foramina	110	127	150
Distance across the articular surface for the occipital condyles	73	75	90
Width across the articular surfaces for the axis	67	77	92

The atlas of the fossil species differs from that of the Arabian horse in having the same width in front as in the rear, instead of widening backward; but variations may here be looked for. In the Arabian the lateral wings droop considerably, so that if a line be drawn from the border of one to that of the other, passing just behind the tuberosity on the lower face of the lower arch, this line will fall much below the border of the articular surface, while in the fossil species the line will touch the border of the articular surfaces at the midline. In *E. hemionus* the line falls a very little below the articular surface. In the fossil the distance across the anterior articular surfaces is greater, as compared with the length along the upper arch, than in the Arabian horse.

The axis is represented by only a fragment which clings in the matrix in the rear of the atlas. The bone was undoubtedly present in its natural position when the skeleton was found.

What appears to be the third cervical is represented by the hinder part. Its length can not be determined. The width across the hinder articular processes was very close to 64 mm. In the Arabian horse it is 70 mm. The width of the hinder articular cup is 34 mm.; in the Arabian, 45 mm. At about the middle of the length the spinal canal had a height of 22 mm. and a width of 24 mm.

The first dorsal is in part present. The anterior end and most of the spinous process are missing. The distance from the outer border of the articular cup for the head of the rib to the corresponding point on the opposite side is 51 mm.

The second dorsal is represented by the greater part of the body and the base of the spinous process.

Measurements of the second dorsal vertebra in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length of the centrum	38	38	45
Vertical diameter of anterior articular head	27	29	36
Lateral diameter of anterior articular head	28	27	33
Width from outside to outside of hinder cavities for head of ribs	50	56	60

What appear to be the sixth, seventh, and eighth dorsals are articulated together and still partly enclosed in the matrix. The spinous processes are missing. The length of the three centra taken together is 96 mm. In the Arabian horse the corresponding measurement is 110 mm. On the left side of the three vertebrae are the cavities for the heads of three ribs, while on the right side there are the bases of three ribs. Three other dorsals, much damaged, form a mass and bear with them the bases of two ribs.

The lumbar vertebrae are represented by the first, second, third, and the hindermost. The spinous processes are missing from all and the lateral processes from all except the hindermost. A part of the articular head of the first is gone. The length of the three centra, taken together, was very close to 122 mm. The dimensions of the third lumbar are as follows:

Measurements of the third lumbar vertebra in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length of centrum	39	41	42±
Height of anterior articular surface	27	26	32
Width of anterior articular surface	30	35	48
Height of posterior articular surface	23	22.5	....
Width of posterior articular surface	37±	43	51
Distance across anterior articular processes	34	40	45

The hindermost, fifth or sixth, lumbar of the specimen is attached to the first sacral. The spine is gone and the outer ends of the transverse processes are broken off. The following measurements are secured:

Measurements of the supposed sixth lumbar vertebra in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length of centrum	± 37	37	±40
Distance between extremities of lateral processes	±185	160	212
Height of anterior articular surface of centrum	20	20	23
Width of anterior articular surface of centrum	37	47	53
Height of spinal canal, in front	19	16	30
Width of spinal canal, in front	24	24	32

The sacrum consists, as usual, of 5 vertebrae, and these are consolidated. The spines are all broken away, except the first one. The following measurements are secured:

Measurements of the sacrum in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Total length of the sacrum along midline	173	175	180
Distance in front between tips of lateral processes	±166	157	211
Distance from outer end of one lateral articular surface for last lumbar to corresponding point on other side	118	122	165
Width at level of front pair of foramina	75	71	95
Width at level of third pair of foramina	48	45	66
Width of hinder end of fifth centrum	27	22.5	28

As will be observed, the sacrum of *E. francisci* lacks but little of being as long as that of the Arabian horse. On the other hand, it is much narrower. Other differences are noted. The free borders of the vertebrae behind the first are in the fossil quite acute, while those of the Arabian horse are thick and rounded. In the latter animal the underside of the sacrum is nearly flat from side to side, the free border just described rising but little above the floor of the spinal canal. In *E. francisci* the sharp border rises at the middle of the third sacral nearly to a level above the middle of the height of the canal. The first vertebra of the tail is preserved. The length of the centrum is 32 mm. The width across the lateral processes at their hinder end is 45 mm.

A fragment of each scapula is preserved. In each there is a triangular piece which presents the coracoid process and the anterior half of the glenoid cavity. The latter has a side to side diameter of 38 mm. In *Equus hemionus* the corresponding diameter is 42 mm. The anterior border rises to a distance of 80 mm. above the lower end of the coracoid.

The humerus is represented by the proximal end of the bone of the right side and the distal end of that of the left. It is impossible to determine the length of the bone. The following dimensions are given as in the species compared:

Measurements of the humerus in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length, total	....	260	317
Length from upper surface of the head to inner side of distal end	....	236	300
Diameter, through the head and tuberosities, greatest	75	83	....
Diameter, greatest at middle of length	....	42	50
Diameter, side to side at middle of length	28±	30	37
Diameter, across the lower articular surface	60	63	80

The left radius has missing a part of the shaft, but the fragments connect in front. The right radius is complete and is accompanied by a part of the proximal end of the ulna. The following are the measurements secured. In the second column under each specific name are presented, as indices, the value of each measurement when compared with the length taken as 100.

Measurements of the radius in millimeters, with indices.

	E. francisci.		*E. hemionus.*		Arabian.	
	Mm.	Indices.	Mm.	Indices.	Mm	Indices.
Length from articular surface above to that below, on outer border of the bone	288	100	300	100	352	100
Diameter of upper end, greatest	69	24	69	23	85	24.2
Diameter at middle of length, fore and aft	23	8	23	7.7	29	8.2
Diameter at middle of length, side to side	33	11.4	35	11.7	40	11.3
Diameter at lower end, greatest from side to side	59	20.5	66	22	80	22.7
Distance across lower articular surfaces, side to side	49	16	54	18	67	19

An examination of this table shows that the radius of *E. francisci* stands in slenderness between that of *E. hemionus* and the Arabian horse, but the distal end is narrower than that of either of the two last named. It is to be observed further that this radius lacks only 2 mm. of being as long as that of the horse whose limbs are in this paper assigned provisionally to *E. laurentius* (p. 569), while the diameters at the middle of the length are far less. The ulna, at the rear of its union with the radius, has a diameter of 33 mm. In *Equus hemionus* it is 42 mm.

Of the ossa innominata there are present three fragments of the right side and four of the left. All parts of the latter are present except the anterior outer process of the ilium, that part of the ischium which enters into the acetabulum and forms most of the hinder boundary of the ischiopubic foramen, and the tuberosity. From the fact that some fragments of the pelvis are missing it is not possible to give all the measurements desired. If a line be drawn from the extremity of the suprailiac crest to the ischial border of the os innominatum, at right angles to this border and following the curvature of the bone, the distance is 175 mm. In *E. hemionus* the distance is 170 mm. Where the ilium is narrowest the diameters are 34 mm. and 20 mm. In *E. hemionus* the corresponding diameters are 32 mm. and 17 mm. The distance from the middle of the superior border of the acetabulum, measured along the axis of the ilium, to the anterior border is almost exactly the same in the two species, 187 mm.

In *E. francisci* the pubic border continues forward as a sharp ridge much further than it does in *E. hemionus*, in which it disappears at a point about 50 mm. in front of the acetabulum. As the hinder portion of the acetabulum is missing the diameter of this can not be determined. The left pubis as preserved appears to reach the symphysis, and there is also a fragment of the right one. The distance from the symphysis in a straight line to the outside of the acetabulum is 106 mm., the same as in *E. hemionus*. The anterior border is sharper than in the latter animal, while that part which forms the anterior boundary of the ischio-pubic foramen is nearly flat. The section of the pubis at this point is thus triangular.

The size of the ischio-pubic foramen can not be determined, but it must have been much larger than in *E. hemionus*, where the greater diameter is only about 40 mm. In the Texas horse it could hardly have been less than 60 mm. It is further evident that the ischium extended backward a considerably less distance than in *E. hemionus*. In the latter the distance from the hindermost border of the ischio-pubic foramen to the hinder border of the ischium, measured 20 mm. from the symphysis, is 110 mm.; in *E. francisci* the distance is 75 mm., but this diminution is partly due to the greater size of the foramen. The ischial tuberosities are missing in the Texas specimen. In *Equus hemionus* the thickness of the bone between the two foramina is 25 mm.; in *E. francisci* about 10 mm.

The right femur is represented by the head and trochanters and by that part of the distal end which bears the articular surface for the patella. Of the left femur there are present the head and a part of the great trochanter, a portion of the shaft, and the inner half of the distal end. The latter part is broken into two pieces, one being the condyle, the other the tuberosity for the support of the patella.

Measurements of the femur in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length of the femur, total		342	425
Length of the femur from head to distal end, inner side		308	380
Diameter through head and great trochanter	91	98	120
Diameter of head, fore and aft	48	48	61
Greatest traverse diameter at middle of length	±50	46	47
Greatest side to side diameter at distal end		81	100
Diameter of inner condyle, side to side	27	30	37
Diameter of outer condyle, side to side	26	28	35
Greatest side-to-side diameter through ridges bounding groove for patella	53	52	64

The greatest diameter at the middle of the femur is taken through the ridge which descends from the third trochanter. This is more prominent in *E. francisci* than in *E. hemionus*. Also, as shown by section, the marrow cavity in *E. hemionus* is of less diameter than is the fossil species, and the bone of the shaft is considerably thicker. In the fossil the ridge which descends from the lesser trochanter is more prominent than in *E. hemionus*.

Both patellae are present.

Measurements of patella in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Total length	54	57	74
Greatest width	55	56	74
Greatest thickness	26	27	....

The tibiae are represented by a fragment of the upper end of that of the left side; that is, the articular surface for the outer condyle of the femur. There is also a large part of the shaft of the one of the right side, including the distal end; also a part of the upper articular surface for the inner condyle of the femur. The length of the bone can not be determined with exactitude, but by comparison of similar surfaces and markings it is estimated that the length was not much less than that of the tibia here assigned to *Equus laurentius* (p. 569), which is 322 mm. The total length of the fragment of the right tibia is 220 mm. The nutrient foramen is not present, but could not have been far away.

Measurements of the tibia in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Total length	....	332	380
Diameter of upper end, greatest, side to side	....	83	102
Diameter at middle of length, fore and aft	±30	29	36
Diameter at middle of length, side to side	±35	37	40
Diameter at distal end, side to side	55	63	80
Diameter at distal end, fore and aft	38	40	51

The diameters taken at the middle of the length are very close to the true ones. The difficulty is, of course, to determine exactly where the middle of the length is. The fragment of the left tibia does not extend across the proximal end. The surface for the outer condyle of the femur measures along its outer border 44 mm.; along the diameter at right angles to this, 36 mm.

All the bones of the left hind foot are present except the hoof phalange and the sesamoids. Parts of the shaft of the third metatarsal are gone, but there is connection throughout the length of the bone. The distal halves of the second and fourth metatarsals are gone. Of the right foot there are present the astragalus, the calcaneum, the cuboid, three fragments of the third metatarsal and the upper third of the second. To the writer it appears possible that the second phalange in the mounted left hind leg is really that of a fore foot, since the width of its upper articular surface is about 3 mm. greater than that of the distal end of the first phalange. The astragali of both sides are complete.

Measurements of the astragalus in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Length of longest diagonal across upper articular surfaces	60	65	80
Width across distal articular surface	40	42	56

Both calcanea are preserved. The following measurements are presented:

Measurements of the calcaneum in millimeters.

	E. francisci.	*E. hemionus.*	Arabian.
Extreme length	96	104	119
Depth of tuber calcis at middle of length	38	38	44

The navicular has a side-to-side diameter of 39 mm. and a thickness of 9 mm. in front. The external cuneiform has corresponding diameters of 38 mm. and 11 mm.; the middle cuneiform measures on its hinder face 27 mm. from side to side; vertically, 16 mm. The cuboid has the greatest diameter, 34 mm.; the vertical diameter, 21 mm.; and the side-to-side diameter, 14 mm. At its distal end each presents an articular surface for the fourth metatarsal. The greater part of both third metatarsals is preserved. That of the right side is in three pieces and portions between them are missing. On the left side the bone is continuous from one end to the other. The following measurements and indices are furnished:

Measurements of the third metatarsal in millimeters, with indices.

	E. francisci.		*E. hemionus.*		Arabian.	
	mm.	*indices.*	*mm.*	*indices.*	*mm.*	*indices.*
Lenth along outer border	225	100	257	100	290	100
Side-to-side diameter at upper articular surface	39	17.3	39	15.1	53	18.3
Fore-and-aft diameter at middle of length	25	11.1	25	9.7	33	11.3
Side-to-side diameter at middle of length	26	11.2	27	10.5	33	11.3
Distance across lower articular surface	34	15.1	40	15.5	53	18.3

A study of this table shows that while the median metatarsal of *E. francisci* is a shorter bone than that of either of the other species, it is intermediate between them in its diameters relatively to its length. The bases of the second and fourth metatarsals of both sides are present, but as their distal ends are missing nothing can be determined regarding their length. The greatest diameter at the base of the second is 15 mm. The greatest diameter of the fourth somewhat below the articular surface is 22 mm. The corresponding diameter in the same bones of *Equus hemionus* are, respectively, 14 mm. and 20 mm. The first and second phalanges of the third digit present the following measurements and indices:

Measurements of phalanges of hinder foot in millimeters, with indices.

	E. francisci.		*E. hemionus.*		Arabian.	
	mm.	*indices.*	*mm.*	*indices.*	*mm.*	*indices.*
Length of first phalange along the outer border	69	100	70	100	81	100
Width across upper end, greatest	36	52.2	43	61.4	58	71.5
Side to side diameter at middle of length	21.5	31.2	25	35.7	33	40.7
Width across distal articular surface	29	42	33.5	47.8	45	55.5
Length of second phalange along the outer border	28	100	36	100	36	100
Width across upper end	34	120.4	39	108.3	55	152.7
Width across lower articular surfaces	29	103.6	35	97.2	51	141.6

It will be observed that the first phalange has almost exactly the same length as that of *E. hemionus*, but in all of its diameters it is smaller. On the other hand, the second phalange is considerably shorter but relatively broader. None of the hoof phalanges of *E. francisci* has been preserved.

On making a comparison between the lengths of the radius, the third metatarsal and the hinder first phalange of *E. francisci* with the lengths of the corresponding bones of the Davenport Arabian horse, already mentioned as having had a height of 14.2 hands, the conclusion is reached that the former had a height at the shoulders of about 11.4 hands, 45.6 inches, 1,159 mm. Accepting this result and making a computation as to the relative sizes of the head in the two species, it will be found that that of *E. francisci* ought to have a basilar length of 395 mm.; this length is, in fact, 414 mm.

3. MEASUREMENTS AND INDICES OF SKULLS OF VARIOUS EQUIDS.

It is not the intention of the writer to enter upon any exhaustive discussion of the horses of the Pleistocene of Europe. It would require much time to study the abundant literature on this subject; likewise, the opportunity would be needed to examine at first hand the materials which have accumulated in European museums. Nevertheless, it must be granted that the American species of *Equus* are closely related to those of the Old World, and that in the study of the former the latter must not be neglected. Researches in Europe have demonstrated that in that country wild horses, resembling closely some of the domestic breeds, have existed from the time of the late Pliocene down to historical times. How these were related to the domestic races and breeds has been and is yet a much-discussed question. Although some authors have held the opinion that the domestic horse was introduced into Europe by westward-wandering primitive men, there has been exhibited more recently a strong tendency to regard all the forms of *Equus caballus* as either the descendants of a primitive race of this species or as the product of the mingling of two or more races, all of which lived in Europe and to all of which the name *caballus* is to be applied. Lately there has been shown again a disposition to withdraw from the abundant Pleistocene forms some which are to be regarded as distinct species. So far as this can be done safely it will greatly assist in clarifying the situation.

One who examines even only cursorily the literature on European Pleistocene horses and on the derivation of our domestic horses must be struck by the lavishness which has been exhibited in the application of systematic names. Sanson recognized eight species, or races, of existing horses belonging to the form known as *Equus caballus*, and to these were given trinomial names; but before Sanson's time Fitzinger described 5 distinct species; 23 races, whose names were expressed by trinomials; and about 120 breeds, for which quadrinomial names were coined. And the employment of quadrinomials appears not yet to have ceased.

Dr. Ewald Wüst has published[1] a description and illustrations of a fossil horse which he regarded as a new species. This horse had been found near Süssenborn, Thuringia, in a deposit of gravel which Wüst believed had been laid down during the first interglacial stage. This would correspond to our own Aftonian. The type of Wüst's species presents the cheek-teeth of the upper and the lower jaws. On account of the extraordinarily large size of these teeth, because of the complexity of the enamel of the lakes and especially of the great inner valley, and because of the deep grooving of the protocone, and finally because of certain features in the lower premolars and molars, the present writer believes that this horse forms a species entirely distinct from anything to which the term *Equus caballus* can with any kind of propriety be applied.

One can hardly praise too highly several of the disquisitions which have been written on the osteology of the horse, in which the utmost patience and exactitude have been shown in taking measurements and in correlating them. Nehring[2] especially indicated a Pleistocene element, which has entered into the formation of the larger and heavier races of domestic horses, and suggested the origin of the smaller forms. Nevertheless, to the writer it appears that to Ewart and Stej-

[1] Abhandl. naturf. Gesellsch. Halle, vol. 23, 1901, pp. 287–296, pls. 6, 7.
[2] Landw. Jahrb., vol. 13, 1884, p. 156.

neger must be given largely the credit for having put the matter on a basis which appears likely to prove satisfactory. According to Ewart's results the modern breeds of horses are mixtures in varying proportions of three distinct forms. The first of these has been called by him *Equus caballus celticus* and, according to him, is represented by small horses found in Iceland, in Connemara (Ireland), in the Hebrides, and the Faroe Islands. The second form is the horse known as *Equus przevalskii*, which exists now wild in the desert of Gobi. The third form has been named by Ewart the Norse, or Forest, horse, and is represented, according to him, by certain horses which occur in northern Europe, especially in northern Scotland. Ewart was inclined at first to regard the Celtic pony as a distinct species; but in an important paper [1] published in 1907 he speaks of it as the Plateau, or Celtic variety. Ewart's characterization of the Forest horse is presented in the work just mentioned, but more fully in the Proceedings of the same society (vol. 26, 1906, p. 8). The Przevalsky horse is designated by Ewart the Steppe variety.

In 1907 [2] Stejneger pointed out that the Celtic pony is found commonly along the entire western coast of Norway and is known as the fjord horse. He associated it with the tarpan, a horse of the steppe region of southern Russia, and regards these two horses as constituting a distinct species. As a representative of Ewart's Norse, or Forest, horse Stejneger mentions another horse of Norway, occupying the interior and eastern part of the country and known as the Gudbrandsdal horse. This, too, he looks upon as a distinct species, which includes the various heavy European horses, which must bear the name *Equus frisius* (Boddaert).

Ewart concluded that (1) the Forest horse is characterized by a short, broad, and dished face, which is not much bent on the base of the skull; that (2) the Plateau, or Celtic, variety has a narrow skull, with broad brain case and with the face little bent on the basicranial axis; while (3) the Steppe variety has a long, narrow skull, in which the axis of the face makes a large angle with the basicranial axis.

There exists a great amount of confusion regarding the types of horses involved in the discussion and regarding their characteristics. Ewart and Stejneger appear to be agreed that the Celtic ponies and the fjord horses belong together. Ewart has announced as a feature which distinguishes the Celtic pony from his Forest horses the narrowness of the skull of the former. On the other hand, Stejneger [3] has given the measurements of a skull of a pony from the Loffoden Islands, the cephalic index, of which, obtained by dividing the frontal width by the basilar length and multiplying by 100, equals 46.

[1] Trans. Roy. Soc. Edinburgh, vol. 4, pp. 555–587.

[2] Smiths. Misc. Proc., vol. 48, p. 469.

[3] Idem, p. 473.

Ewart,[1] too, has furnished some measurements and indices obtained from another skull of a Celtic pony. He has not given the basilar length of the specimen; but a careful estimate shows that this must have been close to 437 mm. Its celphalic index is, therefore, very close to 43.7. While the latter falls somewhat below the former, the indices show that both horses belong among those called by Nehring broad-faced. These two horses will be referred to later; but the writer does not at present see how Ewart's Celtic horses and his Forest horses are to be distinguished by means of skull measurements.

In 1908 [2] Duerst discussed the origin of the various races of domestic horses. He, too, concluded (pp. 399, 431) that our modern breeds have arisen from three types, to which he applied the names "the type of the steppe," "the type of the desert," and "the type of the woods." These names do not, in all cases at least, correspond to those employed by Ewart. Duerst's steppe horse is represented by Nehring's *Equus caballus germanicus robustus;* his "type of the woods," or "forest type," has as its representative *Equus caballus nehringi*, from which, in Duerst's opinion, sprang the Celtic pony; finally, Duerst's type of the desert is his "*Equus caballus pumpellii*," which is "ancestrally closely related to the *Equus przewalskii* Poljakoff." These views illustrate the confusion of the subject; but, what is more important, they seem to justify the view that nobody knows exactly how forest horses, steppe horses, plateau horses, and desert horses differ one from another.

Much time and patience and talent have been expended in measuring the skulls and other bony structures of the domestic horses, and many "indices" have been determined. *Equus caballus* may be regarded as the product of two or three distinct races or species and as having been greatly affected by domestication and breeding. Under these conditions it is proper to inquire whether any of the indices obtained from the skulls of this group are of any value in distinguishing species; and if so, which ones? Also whether they can be employed in determining the ancestors from which the domestic horses have come. It seems essential that these indices should first be tested on unmixed and undomesticated species; and there appears to be no reason why this should not now be done. Already many measurements of *Equus asinus*, *E. hemionus*, and *E. przevalskii* have been published, besides those of a few species of zebras. In the United States National Museum there is now a considerable number of skulls of zebras of two species and of some subspecies of one of these; and doubtless there are other specimens in other museums.

[1] Trans. Roy. Soc. Edinburgh, vol. 45, p. 586.

[2] Publication 73, Carnegie Inst., Washington, vol. 2, pt. 6.

From careful measurements of these and comparison of the measurements some important results may be secured.

Therefore, from the tables presented by Nehring, Tscherski, and Salensky and from measurements made on specimens in the United States National Museum and in the American Museum of Natural History, the writer has prepared a number of tables, which follow. The measurements used are: The basilar length; the vertex length (from the middle of the occipital crest to the incisive border); frontal width (greatest width at the rear of the orbits); the cranial length (distance from the middle of the occipital crest to the middle of the line joining the rear of the orbits); the facial length (the distance from the incisive border to the middle of the orbital line just described); the distance from the lower border of the foramen magnum to the notch in the rear of the vomer; and the distance from the vomerine notch to the rear of the hard palate. The cranial length is obtained by first measuring from the midline of the occipital crest to the rear of the orbit. This distance is made the hypothenuse of a right-angled triangle whose base is half of the frontal width. The other side, representing the cranial length, is then determined mechanically and, if necessary, confirmed arithmetically. The result is believed to be more exact than that obtained by direct measurement on the surface of the skull.

The following table has been partly compiled and partly computed from one specimen measured by Tscherski, from the measurements of five horses, as given by Salensky in his work on *Equus przevalskii*, and from three specimens in the American Museum of Natural History. Only adult specimens have been considered.

Measurements of skulls of Equus przevalskii in millimeters, with indices.

Specimen.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Craniocephalic index.	Facial length.	Faciocephalic index.	For. mag. to vomer.	Vomer to palate.
5218, Salensky	481	543	201	41.2	175	36.4	376	78.2	118	105
212, Salensky	472	528	202	42.8	170	36.0	364	77.1	125	110
5214, Salensky	484	538	208	42.9	172	35.5	366	75.6	117	110
5216, Salensky	495	547	209	42.2	169	34.1	377	76.2	123	109
5213, Salensky	485	542	212	43.7	173	35.6	373	76.9	119	105
512, Tscherski	440	488	188	42.6	150	34.1	335	76.1	112	100
32686, Am. Mus	493	550	212	43.0	176	35.7	380	77.1	119	103
136, Am. Mus	480	532	208	43.4	167	34.8	368	76.6	125	96
71. Am. Mus	457	507	200	43.7	155	33.9	351	76.8	121	92
Averages	476	531	204	42.9	171	35.1	363	76.7	120	103

As regards the basilar length, it will be observed that the difference between that of the largest skull and the smallest one is only 55 mm., and that the difference between the greatest frontal width and the least is only 24.5 mm. As to the cephalic index, which shows the relation of the width of the skull to the basilar length, the variation forms less than 6 per cent of the mean. It will be seen, too, that the cranio-cephalic index shows relatively little variation. The greatest and the least are found in two of the skulls in the American Museum of Natural History. The variation in the length of the face, as shown by the facio-cephalic index, is less than 3.5 per cent of the mean. The position of the notch in the vomer is more subject to variation; in one case only is it nearer the foramen magnum than to the rear of the hard palate.

Salensky[1] has discussed the slight range of variation in the skull of this species.

Coming now to the zebras, the writer here presents measurements and indices of eight adult skulls of *Equus grevyi*, of eight of *Equus quagga granti*, of two of *E. quagga chapmani*, of three specimens of *E. quagga crawshayi*, of one of *E. quagga böhmi*, and of one of *E. quagga cunninghami*. All of these, now in the United States National Museum, (except Crawshay's zebra, obtained by H. C. Moore in central South Africa) were collected in British East Africa by Theodore Roosevelt, Kermit Roosevelt, E. A. Mearns, Edward Heller, and J. A. Loring. The first species considered is *Equus grevyi*.

Measurements of skulls of Equus grevyi in millimeters, with indices.

Specimens in U. S. National Museum.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
163228 ♀	545	615	218	40.0	200	36.5	422	77.4	130	145
182027 ♂	528	590	216	40.5	187	35.4	413	78.2	132	158
182063 ♂	558	615	209	37.4	190	34.0	428	76.7	134	136
163338 ♂	557	627	210	37.7	190	34.1	443	76.8	130	140
163331 ♀	556	632	213	38.3	202	36.3	437	78.6	131	141
182028 ♀	537	600	210	39.1	189	35.2	415	77.3	136	132
163334 ♀	536	600	202	37.6	191	35.6	410	76.5	128	142
182026 ♀	525	595	205	39.0	190	36.2	408	77.7	122	135
Averages	543	609	210	38.7	192	35.4	422	77.4	130	141

There is observed here but little variation in the length and the width of the eight skulls measured. The cephalic index varies beyond the mean not as much as 5 per cent, and the difference between the extremes only 8 per cent. The index is very low, and this horse is the most narrow-headed one known. The facio-cephalic index neither rises above nor falls below the mean more than 1.5 per cent. The cranio-cephalic index is very stable, and the facio-cephalic still more so. The vomerine notch is usually nearer the foramen magnum, as in the domestic ass.

[1] The Przevalsky Horse, Bradley and Hayes Translation, p. 28.

Measurements of skulls of Equus quagga granti in millimeters, with indices.

Specimens in U. S. National Museum.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Craniocephalic index.	Facial length.	Faciocephalic index.	For. mag. to vomer.	Vomer to palate.
161930 ♂	440	486	185	42.0	157	35.7	335	76.1	108	100
162957 ♀	437	498	190	43.5	171	39.1	328	75.1	107	102
161929 ♂	443	510	181	41.4	180	41.5	335	77.3	113	110
162950 ♂	475	538	194	40.8	176	37.1	370	77.9	108	120
181947 ♂	447	513	183	40.9	173	38.7	345	77.2	108	113
162953 ♀	440	508	188	42.7	175	39.7	344	78.2	105	104
162239 ♀	437	498	185	42.3	158	36.1	335	76.6	107	108
162960 ♂	427	500	182	42.6	167	36.5	333	78.0	110	100
Averages	443	506	186	42.0	170	38.5	341	77.1	108	107

Among the eight skulls of this subspecies there is found to be a difference of 48 mm. between the longest and the shortest basilar length, and there is a difference of only 13 mm. between the greatest and the least frontal width. The cephalic index passes neither above nor below the mean more than about 3.5 per cent, and the difference between the highest and the lowest amounts to less than 6.5 per cent of the mean; the facio-cephalic index varies still less. The vomerine notch is near the median point between the foramen magnum and the hard palate.

Measurements of skulls of Equus quagga crawshayi in millimeters, with indices.

Specimens in U. S. National Museum.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Craniocephalic index.	Facial length.	Faciocephalic index.	For. mag. to vomer.	Vomer to palate.
61744 ♂	462	525	177	38.3	165	35.7	365	79.0	108	106
38212 ♀	432	505	181	41.9	168	38.9	341	78.9	108	108
38211 ♂	471	541	195	41.4	191	40.5	364	77.3	126	101
Averages	441	524	184	40.5	175	38.4	357	78.4	114	105

Of the subspecies *Equus quagga crawshayi* there are in the United States National Museum only three skulls. In size, as represented by the basilar length, they are all within the limits of the skulls of Grant's zebra. The cephalic index of one specimen falls to 38.3, as low as in some skulls of Grevy's zebra, but in the others the index is nearly up to the average found in Grant's zebra. The index 38.3 falls below the average of that of Grant's zebra less than 9 per cent. The small number of specimens measured makes it impossible to determine whether or not this is an abnormal individual or whether there is great variability in this form. And attention may be here called to the fact that in these lists it is just in those cases where there are few individuals measured that there are found the greatest differences. This fact is illustrated likewise in the two following tables.

Measurements of skulls of Equus quagga chapmani in millimeters, with indices.

Specimens.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
5239, Salensky	448	501	202	45.1	165	36.8	344	76.8	106	109
5240, Salensky	452	513	184	40.7	159	35.2	356	78.7	106	112
Averages	450	507	193	42.9	162	36.0	350	77.7	106	111

In the case of Salensky's specimen (No. 5239) of Chapman's zebra one might reasonably suspect some error. If the measurements and indices are compared with those of *Equus hemionus*, the two sets will be found to be remarkably similar.

Measurements of skulls of Equus q. böhmi and E. q. cunninghami in millimeters, with indices.

Specimens in U. S. National Museum.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
E. q. böhmi, 181825	488	560	192	39.3	194	39.7	370	77.9	127	114
E. q. cunninghami, 182156	435	500	188	43.0	166	38.2	335	77.0	109	102

If now there are determined the averages of the measurements and indices of all the specimens of Grant's, Crawshay's, Chapman's, Boehm's, and Cunningham's zebras, leaving out only the suspected specimen of Chapman's mentioned above, there are obtained the following:

Combined measurements and indices of subspecies of Equus quagga in millimeters.

	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.
Averages	446	514	186	41.6	172	38.3	347	77.5

By considering the difference between the greatest and the least values shown in each of the respective columns devoted to the various subspecies and bringing them into comparison with the corresponding average it will be seen that the basilar length varies by an amount less than 14 per cent of the average; the frontal width less than 10 per cent; the facial length about 12 per cent. The cephalic index varies to the extent of 12.5 per cent of the mean. The variation of the cranio-cephalic index is greater, about 21.5 per cent. Within the subspecies *granti* it varies to the extent of 15 per cent. It seems possible that the wide range here may be due to the greater or less development of the occipital crest; not improbably the brain is considerably larger in some individuals than in others.

The elements from which the following table has been prepared are found in Nehring's and Salensky's papers.

Measurements of skulls of Equus zebra in millimeters, with indices.

Specimen.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
800, Nehring	446	504	180	40.4	161	36.1	334	74.9	100	112
1450, Nehring	451	520	184	40.8	168	37.2	356	78.9	113	....
799, Nehring	492	555	205	41.6	191	38.8	379	77.0	130	114
5238, Salensky	485	555	187	38.6	188	38.7	375	77.3	119	114
111, Salensky	437	483	201	45.9	173	39.6	321	73.4	112	103
Averages	462	523	191	41.4	176	38.1	353	76.3	115	111

Among the skulls represented here there is a remarkable amount of variation, and this appears especially in the two sets of measurements furnished by Salensky. The first of these two has a skull as narrow as the average of those of *E. grevyi*, while the second skull is as wide as that of some of the asses. Indeed, this second skull resembles closely the last one in the list of those of *E. asinus*. In case this skull should be left out of the estimate as being that of an unusually developed beast or as possibly not of this species, the cephalic index would be 40.4, and the variation between the lowest and the highest value would be less than 7.4 per cent of the mean. In other respects the species, as represented, would show close conformity to its type.

Consideration will now be given to some of the forms which pass under the name of asses. *Equus asinus* is included, although a domesticated animal.

Measurements of skulls of Equus hemionus in millimeters, with indices.

Specimens.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
513, Salensky	427	487	197	46.1	160	37.5	338	79.1	95	122
1075, Salensky	445	499	197	44.2	163	36.6	343	77.1	105	112
516, Salensky	436	498	198	45.4	155	35.5	341	78.2	105	113
515, Salensky	465	529	202	43.4	166	35.7	374	80.4	116	110
511, Salensky	463	529	204	44.1	167	36.1	368	79.5	106	120
217, Salensky	468	525	209	44.6	167	35.7	361	77.1	115	103
224, Salensky	469	520	196	41.8	171	36.4	358	76.3	111	128
515, Tscherski	472	522	201	42.7	163	34.5	364	75.9	115	110
Averages	456	514	201	44.1	164	36.0	355	77.9	109	115

A study of this table shows that there is a difference of 45 mm. between the greatest basilar length and the least. This difference equals less than 10 per cent of the average length. Between the widest and the narrowest skull there is a difference of only 13 mm. The cephalic index presents an extreme variation of about 9 per cent of the average. The cranio-cephalic index shows a variation amounting to 8.3 per cent of the mean, while the facio-cephalic index varies to an amount equaling 5.8 per cent.

The following measurements and indices have been obtained from data furnished by Nehring, Tscherski, Salensky, and from a skull which is in the United States National Museum, and which was obtained in southern Kashmir.

Measurements of skulls of Equus kiang in millimeters, with indices.

Specimens.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
3874, Salensky	474	540	218	46.0	166	35.0	374	78.9	110	113
5227, Salensky	449	508	202	45.0	167	35.0	349	77.1	128	107
3874, Tscherski	482	544	219	45.4	169	35.1	377	78.2	111	127
30, Nehring	470	525	209	44.5	169	35.9	359	76.4	113	117
49493, U. S. Nat. Mus	450	500	205	45.5	165	36.6	345	76.7	111	118
Averages	465	523	211	45.3	167	35.5	361	77.5	115	116

We have here a species which conforms in many respects more closely to an average than does *Equus hemionus*. The basilar length varies in the five individuals only 32 mm., which equals not quite 7 per cent of the mean. The cephalic index shows a range of variation equaling only 3.3 per cent of the average. The cranio-cephalic index presents a range of only 4.5 per cent, and the facio-cephalic index one of only 3.3 per cent.

The following table is based on measurements of eleven skulls of the domestic ass. These are taken mostly from Nehring, Tscherski, and Salensky. Three skulls in the American Museum of Natural History furnished additional data.

Measurements of skulls of Equus asinus in millimeters, with indices.

Specimens.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
1, Nehring	353	407	170	48.1	151	42.8	260	73.6	80	90
2, Nehring	360	410	176	48.8	144	40.0	270	75.0	88	95
3, Nehring	360	415	181	50.3	142	39.4	281	78.1	91	93
5, Nehring	370	422	191	51.6	153	41.4	270	73.0	86	97
1136, Tscherski	365	408	166	45.4	145	39.7	265	72.6	87	95
1142, Tscherski	370	424	173	46.7	155	41.9	271	73.3	86	98
114, Tscherski	401	445	190	47.4	162	40.4	283	70.6	99	107
1136, Salensky	362	410	167	46.1	141	38.9	264	72.5	87	93
1142, Salensky	365	424	176	48.2	153	41.9	274	75.1	86	96
107, Amer. Museum	390	442	182	46.7	158	40.5	289	74.1	95	107
15675, Am. Museum	425	485	200	47.1	171	40.2	318	74.8	98	112
Averages	375	427	175	47.8	152	40.6	277	73.9	89	98

Among the eleven individuals here represented there is a variation of only 72 mm. in the basilar length and 34 mm. in the frontal width. A specimen measured by Nehring had, however, a basilar length of 504 mm. A consideration of the cephalic index shows a greater range of variation, amounting to nearly 13 per cent of the mean. The extremes of variation in the cranio-cephalic and the facio-cephalic indices amount to about 10 per cent of the mean. The face is on an average considerably shorter than that of any others of the Equidae here considered; but cases occur in which it is about as long as that of any of the others. This shows that it is not safe to trust wholly to any single character in determining species. The vomerine notch is nearer the foramen magnum than to the palate in the specimen considered, but the difference is sometimes small. In consideration of the fact that those species which are represented by a considerable number of skulls usually show much less variation than do those of the domestic ass, is it not allowable to suppose that the wide variations of the latter are due to domestication?

The materials which have been used in constructing the following table have been found in the schedule of measurements and indices of sixty skulls of Equidae furnished by Nehring in the work already referred to. Besides skulls referred to *Equus caballas*, Nehring considered the asses and the zebras. The skulls of his list are arranged in the order of their basilar length, beginning with the lowest. From this list the present writer has selected eight skulls near the beginning and eight from near the end of it, thus getting a group of small horses and another of large ones.

Measurements in millimeters and indices of domestic horses.

Numbers of specimens in Nehring's list.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
13	426	464	190	44.3	151	35.5	320	75.1	111	92
14	438	490	201	45.9	162	36.9	327	74.6	119	89
15	438	492	201	45.9	158	36.1	342	78.1	107	97
16	443	490	193	43.5	162	36.6	333	75.2	111	99
18	448	492	202	45.1	163	36.4	357	79.8	119	93
20	450	490	189	42.0	158	35.1	343	76.2	109	100
21	450	494	192	42.7	159	35.3	337	74.9	114	95
23	452	500	201	44.5	162	35.8	337	74.5	109	100
49	536	584	222	41.4	190	35.4	396	73.9	142	111
50	542	569	222	41.0	182	33.6	391	72.1	142	114
51	546	587	216	39.5	168	30.8	419	76.7	136	120
52	550	586	214	38.9	176	32.0	410	74.5	143	117
55	558	605	231	41.4	182	32.6	419	75.1	139	116
56	571	615	236	41.3	183	32.1	414	72.5	141	119
57	574	623	238	41.4	191	33.3	434	75.6	145	122
58	585	628	255	43.6	201	34.4	423	72.3	155	121
Averages	500	544	213	42.7	172	34.5	375	75.1	128	107

If we now accept all these skulls as belonging to a single species, *Equus caballus*, we have one which exhibits a very wide range in size and structure. The difference between the basilar length of the smallest and that of the largest skull amounts to 159 mm., nearly 32 per cent of the mean length. The difference between the least frontal width and the greatest is 66 mm., more than 30 per cent of the mean frontal width. The cranial length has a range of 50 mm., which is 29 per cent of the mean length; the facial length, a range of 114 mm., which amounts to somewhat more than 30 per cent of the average length.

Although these things are true, the indices might nevertheless be relatively stable, but we do not find them to be so. The cephalic index varies to an amount somewhat greater than 16 per cent of the mean; the craniocephalic index more than 17 per cent; and the facio-cephalic index more than 11 per cent. No such differences appear in the wild species. It may be contended that these differences are due to domestication; and we do find considerable, but more narrowly limited, variations in the domestic ass. However, there are evidences that similar differences existed among the European horses of the latter half of the Pleistocene; and on these differences has been based the hypothesis that there existed among the Pleistocene a number of races or subspecies of *Equus caballus.*

If now we consider those eight horses in the above list which are placed above the horizontal line we find the following averages:

Averages of measurements in millimeters and indices of small domestic horses.

	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Craniocephalic index.	Facial length.	Faciocephalic index.	For. mag. to vomer.	Vomer to palate.
Average	443	489	196	44.2	159	36.0	337	76.1	112	96

From this table and that from which these averages are obtained it is seen that the cephalic index is high, indicating a broad face. It is seen, too, that the difference between the highest and the lowest expressions amounts to less than 9 per cent of the averages; that the cranio-cephalic index has a range of variation of only 5 per cent of the average, and that the facio-cephalic index has a range of only 7 per cent of the mean.

Considering the eight examples which occupy the lower half of the table on page 559, we find as follows:

Averages of measurements in millimeters and indices of large domestic horses.

	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Craniocephalic index.	Facial length.	Faciocephalic index.	For. mag. to vomer.	Vomer to palate.
Averages	558	600	229	41.1	184	33.0	413	74.1	143	118

From this table we learn that the cephalic index is rather low, the average, 41.1, being slightly below the dividing line which Nehring drew between the narrow-faced and the broad-faced horses (240 according to his method=41.6 according to the method employed here). The fluctuation of this index amounts to 11.4 per cent in the eight specimens measured. The cranio-cephalic index has an average of 33 and a fluctuation of 4.6, which is equal to 14 per cent of the mean; while the facio-cephalic index has a variation of only 6.2 per cent of the mean. It is somewhat remarkable that the cranio-cephalic index varies so little in the broad-skulled group and so much in the narrow-skulled horses. Now, each of these two groups has all the characteristics of structure and proportion of a well-defined species, such as the Przevalsky horse, Grevy's zebra, and the chigetai. There appears to be no necessary relation between a short skull and a wide forehead; and therefore it can not be said that the results are due to having selected the shorter skulled specimens. The eight skulls of Grant's zebra have the average of the basilar length exactly the same as that of the eight small domestic horses, but the frontal width is considerably less and the cranio-cephalic index, too, is less. We need not, therefore, believe that the peculiarities of the two groups is due merely to size; nor can we suppose that the two groups are pure strains. We know that in each there is some admixture of the one with the other; and there may be some mingling of possibly a third constituent.

The writer believes, therefore, that it will be necessary to recognize at least two distinct species among the progenitors of our domestic horses. An objection to this view may be found in the fact that these have bred and do breed freely together; but this objection will apply quite as well against our regarding *Equus przevalskii* as a distinct species. One of the two supposed species is represented in our time by the large narrow-faced horses, such as form the second portion of the table on page 559; the other is represented by the pony-like broad-faced horses, especially the Celtic pony and the fjord horses of Norway. It has been already stated on page 552 that Ewart in his work in the Transactions of the Edinburgh Royal Society has presented certain measurements of a Celtic pony and that estimates showed that its basilar length was close to 437 mm. Accepting this and other measurements given by Ewart, likewise those of a Celtic pony from the Loffoden Islands furnished by Stejneger, there is obtained the following table:

Measurements in millimeters and indices of two Celtic ponies.

Specimen.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.
Ewart's	437	485	192	43.7	170	36.7	333	76.2
Stejneger's	456	....	210	46.3	155	34.0	336	73.7

The specimen measured by Stejneger has an extraordinarily broad face. It is broader, in fact, than either of the skulls of Ewart's two

"Forest horses."[1] It will be observed, too, that the Loffoden specimen has low cranio-cephalic and facio-cephalic indices. Inasmuch as Stejneger regards the tarpan of southern Russia as being co-specific with the Celtic pony, it will be well to include here the data regarding the skulls of two recorded specimens. The elements of the following table are taken from Tscherski's table:

Measurements in millimeters and indices of skulls of the tarpan.

Specimens.	Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
Chersonese	470	512	206	43.6	168	35.7	347	73.8	128	89
Crimean	470.5	520	203	43.1	172	36.5	346	73.5	122	95.5

The measurements and indices of these two specimens are remarkably similar. In size, as shown by the basilar length, they are larger than either of the two ponies recorded in the table just preceding this one. They are also larger than any of the eight small horses found in the table on page 559. Nevertheless, they are not much larger, and are far from having the size of the large horses. In breadth of face they resemble the small horses and Ewart's Celtic pony. In the facio-cephalic index they resemble the Loffoden pony, as well as some of the large narrow-faced group. The chances are that their predecessors had mingled somewhat with the large narrow-faced horses.

To the broad-faced species of the Pleistocene would be assigned horse No. 25 of Nehring's list, found in a peat bog in northern Germany and figured by Nehring on his plate 7. From his measurements the following results are obtained:

Nehring's Tribsees horse.

Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
455	*mm.* 500	*mm.* 204	44.8	*mm.* 163	35.8	*mm.* 333	73.2	*mm.* 110	*mm.* 108

It will be seen that these measurements and indices agree well with those of the smaller domestic horses, except that the size is somewhat greater and that the face is rather shorter than usual on the latter. In this respect it agrees with the tarpan just described.

From the fossil horse, described by Nehring from Remagen and illustrated on his plate 5, the following measurements and indices are obtained:

[1] Trans. Roy. Soc. Edinburgh, vol. 4, p. 586.

Fossil horse from Remagen.

Basilar length.	Vertex length.	Frontal width.	Cephalic index.	Cranial length.	Cranio-cephalic index.	Facial length.	Facio-cephalic index.	For. mag. to vomer.	Vomer to palate.
	mm.	*mm.*		*mm.*		*mm.*		*mm.*	*mm.*
528	562	212?	40.1	180	34.1	388	73.5	139	112

A comparison of the estimates printed here with those of the table of large domestic horses shows that the Remagen horse agrees in all essential respects with the former. This was the conclusion reached by Nehring himself.

It is believed by many that the late Pleistocene ancestors of Przevalsky's horse took part as one of the constituents of *Equus caballus*. A comparison of the table devoted to this species with that dealing with the domestic horses shows that Przevalsky's horse is intermediate in size between the large ones and the small ones; that the cephalic index is intermediate, but nearer the large horses; that the cranio-cephalic index is nearer that of the small horses; and that the facio-cephalic index has an average above both groups. There appears to be no reason whatever for supposing that *E. przevalskii* had anything to do with either of them.

One might suppose, however, that *E. przevalskii* formed an important element in horses of intermediate size. Ewart, for various reasons, believes that this species, or something like it, enters into composition of all the long-faced horses; but the tables here presented show that the large, heavy, apparently long-faced horses have really the facio-cephalic index lower than do the smaller and broad-faced horses. Duerst concludes that the Przevalsky horse stands in close relationship with certain European Pleistocene horses. Salensky thought it might possibly have an affinity to the pony; and Noack, as noted by Ewart, held this view strongly. To these views there are some objections.

1. The presence of *E. przevalskii* in Europe has not been proved. There may have been another species in Europe in the Pleistocene which resembled it, but which became extinct.

2. The inclusion of the Przevalsky horse in *Equus caballus* would compel the admission that in Europe there were, during the late Pleistocene, three distinct species of horses which could be made to breed freely together. It is difficult to believe that two species could be made to interbreed; it is improbable that three could be induced to do so.

3. In case Przevalsky's horse had entered to any considerable extent into the formation of our domestic horses, we might naturally expect that there would be displayed more conspicuously in some of the domestic races those external characters which Salensky has

enumerated, especially the upright mane and the peculiarly haired tail.

It is thought well to present a brief conspectus of the more important average measurements and indices which have been obtained up to this point in the conclusion.

Average measurements in millimeters and indices of Equids considered.

Species.	Basilar length.	Cephalic index.	Cranio-ceph. index.	Facio-ceph. index.	For. mag. to vomer.	Vomer to palate.
E. przevalskii	476	42.9	35.1	76.7	120	103
E. grevyi	543	38.7	35.4	77.4	130	141
E. granti	443	42.0	38.5	77.1	108	107
E. zebra	462	41.4	38.1	76.3	115	111
E. hemionus	456	41.1	36.0	77.9	109	115
E. kiang	465	45.3	35.5	77.5	115	116
E. asinus	375	47.8	40.6	73.9	89	98
8 small horses	443	44.2	36.0	76.1	112	96
8 large horses	558	41.1	33.0	74.1	143	118

It appears to be a common idea that the small, broad-faced horses are likewise short-faced, and that the large horses are long-faced as well as narrow-faced. Relatively the small horses which have been dealt with on page 559 have a greater cranio-cephalic index than the eight large ones, but they have likewise a larger facio-cephalic index. It follows almost of necessity from that table that the vertex length of the small horses is, as measured by the basilar length, greater than in the large horses. In the following table the vertex-length index has been obtained for each of the sixteen skulls used in the table referred to:

Indices of vertex length of domestic horses.

Small horses.		Large horses.	
Number in Nehring's list.	Index.	Number in Nehring's list.	Index.
13	108.9	49	108.9
14	111.9	50	105.0
15	112.3	51	107.5
16	110.6	52	106.5
18	109.8	55	103.4
20	108.9	56	107.7
21	109.8	57	108.5
23	110.6	58	107.4
Average	110.3	Average	107.5

It may seem that we have wandered away from the consideration of the value of craniometrical measurements for the determination of species of horses and their relationships to one another. We may be really in a better position to aid in solving the problems. The conclusions reached at present are as follows:

1. Measurements and indices are of great value in distinguishing certain species of horses from certain others.

The skull of the domestic ass may in the great majority of cases be distinguished from that of all other equids. Grevy's zebra possesses craniometrical characters which set it off quite decidedly from other horses and zebras. The writer believes that measurements and the indices derived from them show plainly that two species are mingled in different proportions in our different races of domestic horses.

2. Not all species can be distinguished by craniometrical methods. It is reasonable to suppose that two or more species might have skulls and skeletons of practically the same size and proportions and yet differ greatly in external characters and perhaps in details of structure of the teeth.

3. In cases where only single skulls of two or more supposed species are at our disposition, as in the case of most fossil horses, the measurements and indices must be employed with circumspection. The measurements of one skull may differ considerably from those of another and yet both belong to the same species, for they may present the extremes which arise from individual variation. Not too much dependence should be placed in any one measurement or in any single index. All ought to be considered, and all other characters ought to be considered in coming to a conclusion.

4. It is difficult to say which measurements and which indices are of the most importance. The basilar length, the cranial length, the facial length, the width at the rear of the orbits, and the indices derived from them are of prime importance. In the application of these to special cases sometimes one index may be of special value; in other cases another index may be decisive.

5. The value of still other indices than those considered in this paper, such as that expressing the angle included between the axis of the cranium and the axis of the face, the index showing the relation of the length of the tooth line to the basilar length, the index expressing the relation of the protocone to the length or width of the tooth, ought to be tested on the Przevalsky horse, the zebras, the chigetai, the kiang, and the domestic ass.

4. ON SOME RESULTS OBTAINED BY W. SOERGEL.

W. Soergel has written an interesting paper entitled Die Pferde aus der Schotterterrasse von Steinheim a. d. Murr.[1] This author has reached certain results which he regards as of great value in determining the phylogenetic position of the various horses of the Pleistocene of Europe (p. 743) and the age of the deposits in which horse teeth may occur (p. 746). While Soergel's results are applied by him only to the horses of the Pleistocene of Europe, they might be supposed to be applicable to those of North America likewise.

[1] Neues Jahrb. Min., etc., Beilage, vol. 32, 1911, pp. 740–761, pls. 33, 35.

On page 743 Soergel writes that in all diluvial forms of horses the relative length of the upper premolar series is the same, the variations being very small and irregular. The present writer has made measurements and calculations to determine what is the ratio of the upper premolars to the whole premolar-molar series (regarded as 100) in the horses named below.

Ratio of upper premolars to premolar-molar series.

Equus francisci, type	54.8
E. hatcheri, type	51.3
E. laurentius, type	54.4
E. niobrarensis, type	54.2
E. scotti, 10628 Amer. Mus.	55.0
E. caballus, 174960 Nat. Mus	53.2
E. caballus, 172454 Nat. Mus., Arabian	56.6
E. hemionus, 49493 Nat. Mus	54.0

All of the fossil species mentioned above belong certainly to the early Pleistocene, *E. niobrarensis* and *E. hatcheri* were obtained in the same quarry. Nevertheless, there is a good deal of variation in the ratios. *E. caballus*, No. 174960, is a large horse with basilar length of 610 mm. and therefore of the occidental type; the ratio here falls below that of *E. niobrarensis*, of the early Pleistocene, in all probability of the first interglacial stage, and still more below the little horse *E. francisci*. Above all stands the ratio in the last horse mentioned, the so-called Arabian.

Soergel makes the statement (p. 743) that in the lower jaw the relative length of the premolars is greater in the phylogenetically older forms than in the more recent. He shows that in the case of *E. stenonis* of the late Pliocene the ratio of the premolar series to the whole tooth-line is 56.0; in *E. süssenbornensis*, of the first interglacial stage, 53.1; in *E. mosbachensis*, also of the first interglacial, 52.6 to 51.7; *E. germanicus?* from Taubach of the third interglacial, 52.1; and *E. germanicus* from the loess, 48.6 to 50.5.

From the specimens from which the present writer obtained the ratios for the upper teeth the following ratios have been determined for the lower cheek-teeth, *E. francisci* being necessarily omitted:

Equus hatcheri	52.1
E. laurentius	50.0
E. niobrarensis	53.0
E. scotti	52.2
E. caballus	51.9
E. caballus	53.0
E. hemionus	51.3

There appear in the above table no evidences that the lower premolar series has become shorter in the horses since the beginning of the Pleistocene. Furthermore, if we go back to *Mesohippus bairdi*, of the Oligocene, we shall find that the premolar series formed only about 48 per cent of the length of the lower premolar-molar series, omitting the minute front premolar (pm_1). The present writer is of the opinion that it would be difficult to prove the proposition that in the horses in general the lower premolar series has become relatively shorter in the more recent than it was in the earlier forms. It would be quite as difficult to prove that the "lobus tertius" of the hindermost molar has increased in length as compared with the whole length of the molar mentioned.

Soergel described and figured a quite complete lower jaw of a horse which had been found at Steinheim. This author has measured the height of the horizontal ramus of his specimen at seven places, as in the table below, and has given the heights in hundredths of the length of the lower row of cheek teeth. For purposes of comparison he has done the same with three other fossil horses of his region and with a specimen of the domestic horse. From his comparisons he has concluded that the height of the lower ramus in the older forms of horses was greater relatively to the tooth row than in the more recent forms; that the reduction in height from the rear forward was more gradual, and that consequently in the older forms this part of the jaw was heavier than in the later horses. To test the applicability of these conclusions to the American Pleistocene horses the present writer has prepared the following table, in which the jaws are measured after Soergel's method. Soergel's measurements of *E. caballus* are included. The horse which furnishes the measurements of the fourth column is the one in the United States National Museum whose basilar length is 610 mm.

Dimensions in jaws in hundredths of the length of the tooth line.

Dimensions taken.	*E. niobrarensis.*	*E. hatcheri.*	*E. caballus* of Sœrgel.	*E. caballus*, U. S. Nat. Mus.	*E. caballus* Arab.
Height behind m_3	71.2	68.1	59.6	65.7	67.2
Height between m_3 and m_2	57.4	57.4	47.6	55.4	53.3
Height between m_2 and m_1	53.0	54.2	44.5	51.1	47.8
Height between m_1 and pm_4	52.4	52.6	41.5	48.9	45.4
Height between pm_4 and pm_3	49.1	50.0	37.8	47.3	43.0
Height between pm_3 and pm_2	44.2	45.7	34.7	41.8	39.4
Height in front of pm_2	38.0	38.3	26.9	37.5	30.3

If now we find in each of the specimens here studied the ratio between the uppermost number in each case and the lowermost we shall have an expression showing the amount of descent in the jaw in going from the rear of the hindermost molar to the front of the anterior premolar. These ratios given in order are: 53.5 for *E. niobrarensis;* 56.2 for *E. hatcheri;* 45.1 for Soergel's *E. caballus;* 57.1 for the large *E. caballus;* and 45.1 for the Arabian. From this it appears that the large specimen of *E. caballus* has a lower jaw which is relatively higher in front than in any of the other specimens, although as a whole it is a less heavy jaw. This large jaw presents a ratio quite different from that of Soergel's specimen, while the jaw of the Arabian presents the same ratio as Soergel's. It needs to be noted that the numbers in the last two columns of the table given above are quite different from those in the third column; and, besides, are somewhat different from each other. The conclusion which one must reach is that there is among the domestic horses and probably all others more or less variability in the lower jaw, as there is in all other structures. Even in any unmixed species the lower jaw must be subject to great variations due to the state of development of the teeth. The author regrets that he has not the time to test on the zebras in the National Museum Soergel's indices and many others which have been proposed.

5. ON THE LIMB BONES OF CERTAIN FOSSIL HORSES.

In the year 1886 John Bell Hatcher made a collection of vertebrate fossils in the region south of the present town of Hay Springs, Nebraska, for Prof. O. C. Marsh, then connected with the United States Geological Survey. From Mr. J. W. Gidley the writer learns that the exact locality is on the south side of the Niobrara River, about 15 miles south of Hay Springs; and it is evidently in township 29 north and 47 west. The fossils occurred in a very restricted area and in a deposit of loose sand. These fossils are now in the National Museum. Dr. W. D. Matthew has given a list of the species of vertebrates found in that neighborhood, probably in the same quarry. Besides extinct horses, the list includes *Mylodon*, *Castoroides*, *Capromeryx*, and three species of camels.[1]

In the collection at the National Museum there have been found packed together in the same box a right fore and a right hind leg complete with corresponding parts of the shoulder and pelvic girdles. They are regarded as having all belonged to the same individual. The fore leg has the number 7863; the hind leg the number of 7924. These were not accompanied in the package by any skulls or teeth, and it is therefore not possible to determine exactly to which one of the several species of horses which lived in that region they belonged. They are here referred provisionally to *Equas laurentius*, the smallest known horse of that region. It is proposed to describe these bones and to make comparisons of them with corresponding bones of an Arabian horse in the National Museum and with some bones of other horses found in the same locality in Nebraska.

In the first, third, fifth, and seventh columns are given the absolute measurements, while in the second, fourth, sixth, and eighth columns are presented the percentages which are obtained by com-

[1] Bull. Amer. Mus. Nat. Hist., vol. 16, p. 317.

parison of the length of some of the bones, called 100, with certain of the transverse measurements.

Measurements, in millimeters, of bones of horses, with indices.

	Arabian.		*Equus laurentius.*		No. 7857.		No. 7923.	
	1	2	3	4	5	6	7	8
Scapula, length from front of glenoid cavity to upper border, along the spine	358	......	325	......	......	......	320	......
Width near upper end, greatest	175	......	175	......	......	......	......	......
Width of neck, where least	68	......	64	......	......	......	64	......
Greatest width at lower end	98	......	88	......	......	......	90	......
Fore and-aft diameter of glenoid cavity	61	......	56	......	......	......	......	......
Humerus, total length	317	......	270	......	292	......	310±	......
Length from head to inner side of distal end	300	100	248	100	282	100	292	100
Greatest width at upper end	123	41	90	36.3	90	31.9	100	34.2
Side-to-side diameter at middle of length	37	12.3	35	13.3	35	12.4	40	13.7
Width across lower articular surface	80	26.7	73	29.4	78	27.6	83	28.4
Ulna, total length to articulation with cuneiform	443	......	372	......	418	......	413	......
Radius, length from upper articular surface to the lower, on the outer border of the bone	352	100	290	100	328	100	325	100
Greatest width at upper end	85	24.2	79	27.2	87	26.5	93	28.5
Fore-and-aft diameter at middle of length	29	8.2	30	9.8	29	8.8	33	10.1
Side-to-side diameter at middle of length	40	11.3	41	14.1	43	13.1	45	13.8
Greatest width near lower end	80	22.7	69	23.8	74	22.5	81	24.8
Greatest width of distal articular surface	67	19	58	20	65	19.8	71	21.8
Median metacarpal, length on outer border	240	100	213	100	222	100	241	100
Side-to-side diameter of upper articular surface	54	22.5	50	23.4	52	23.4	55	22.8
Fore-and-aft diameter at middle of length	29	11.7	27	12.6	29	13.1	32	13.2
Side-to-side diameter at middle of length	33	12.1	34	15.9	35.5	16	40	16.6
Side-to-side diameter of distal articular surface	53	22.1	47	22	52	23.4	53	22
First phalange, length along outer border	83	100	76	100	79	100	87	100
Greatest width across upper end	56	65.9	54	71	62	78.4	61	70.1
Side-to-side diameter at middle of length	35	41.2	36	47.3	34	43	40	46
Width of lower articular surface	47	55.2	43	56.6	47	59.5	52	59.7
Second phalange, length on outer border	35	100	33	100	36	100	41	100
Width across upper end	55	157.1	44	133	55	152.8	59	144
Width at middle of length	47	134.2	41	124	46	127.7	50	122
Width across lower articular surface	54	154.3	43	130.3	51	141.7	53	129.2
Third phalange, length along front face	58	100	55	100	53±	100	55	134.1
Greatest width	84	144.8	68	123.6	76	143.4	77	187.7
Pelvis, length from front of ilium to rear of ischium	445	......	400	......	......	......	......	......
Greatest width near front of ilium, on curve	260	......	252	......	......	......	......	......
From front of ilium to front of acetabulum	265	......	230	......	......	......	......	......
Greatest width of pelvis	467	......	......	......	......	......	......	......
Width of pelvis at front of acetabulum	240	......	......	......	......	......	......	......
Distance across ischia at rear	233	......	......	......	......	......	......	......
Diameter of acetabulum	65	......	60	......	......	......	......	......
Femur, total length	425	......	378	......	......	......	......	......
Length from head to internal condyle	380	100	338	100	......	......	......	......
Side-to-side diameter through head and great trochanter	120	31.6	116	34.3	......	......	......	......
Side-to-side diameter at middle of length	41	10.8	41	12.1	......	......	......	......
Greatest width across lower end	100	26.3	93	27.5	......	......	......	......
Patella, length	74	......	65	......	......	......	......	......
Width	74	......	66	......	......	......	......	......
Tibia, length from upper articular surface to distal end, outside	345	100	292	100	......	......	......	......
Width of upper end	102	29.5	94	32.2	......	......	......	......
Fore-and-aft diameter at middle of length	36	10.4	38	13	......	......	......	......
Side-to-side diameter at middle of length	40	11.6	45	15.4	......	......	......	......
Greatest width at lower end	80	23.2	72	24.6	......	......	......	......
Astragulus, length of longest diagonal across upper articular surfaces	80	......	75	......	......	......	......	......
Width across distal articular surface	56	......	50	......	......	......	......	......
Calcaneum, greatest length	119	......	108	......	......	......	......	......
Depth of tuber calcis at middle of length	44	......	44	......	......	......	......	......
Median metatarsal, length on outer face	290	100	263	100	......	......	......	......
Width across upper articular surface	53	18.3	46	17.5	......	......	......	......
Fore-and-aft diameter at middle of length	33	11.3	34	12.9	......	......	......	......
Side-to-side diameter at middle of length	33	11.3	31	11.7	......	......	......	......
Width of lower articular surface	53	18.3	47	17.8	......	......	......	......
First phalange, length on outer border	81	100	71	100	......	......	......	......
Greatest width across upper end	58	71.5	51	71.8	......	......	......	......
Width across middle of length	33	40.7	31	43.6	......	......	......	......
Width across lower articular surface	45	55.5	38	53.5	......	......	......	......
Second phalange, length on outer border	36	100	35	100	......	......	......	......
Width across upper end	55	152.7	45	128.6	......	......	......	......
Width at middle of length	46	127.7	39	111.4	......	......	......	......
Width across lower articular surface	51	141.6	41	117.1	......	......	......	......
Hoof phalange, length along front face	57	100	53	100	......	......	......	......
Greatest width	78	136.8	65	122.6	......	......	......	......

It is proposed now to determine the length of some of the principal bones here referred provisionally to *Equus laurentius* relative to the corresponding ones of the Arabian horse here measured. In each case the bone of the latter horse is regarded as having the value 100.

Relative measurements of bones of Arabian horse and E. laurentius?

Bones.	Arabian.	*E. laurentius?*
Scapula	100	91.0
Humerus	100	82.7
Radius	100	82.4
Metacarpal	100	88.7
First phalange	100	91.6
Second phalange	100	94.3
Femur	100	88.9
Tibia	100	84.3
Metatarsal 3	100	90.7
First phalange	100	87.6

From the above table it is seen that the larger bones of the hinder limb of the supposed *E. laurentius*, the femur, tibia, and third metatarsal, as compared with those of the Arabian horse, are longer than the corresponding bones of the foreleg; and that the metatarsal is most elongated of all. The distal bones, too, the metacarpal, metatarsal, and first phalanges are seen to have relatively greater length than the proximal bones.

If the lengths of the various bones of the fore limbs of the two species be added together, omitting the scapula and ulna and including 42 mm. for the length of the carpus of the Arabian and 37 mm. for that of *E. laurentius?*, we shall have for the length of the foreleg of the Arabian horse 1,110 mm.; for that of *E. laurentius?* 952 mm. The latter is 85.7 per cent of the former. The height of the Arabian horse is stated by its former owner, the late Mr. Homer Davenport, to have been 14.2 hands. *E. laurentius?* was, therefore, probably close to 12.6 hands high, or 4 feet 2½ inches, or 1,284 mm.

By allowing 86 mm. for the length of the tarsus of the Arabian horse and 75 mm. for that of *E. laurentius?* there is obtained as the partial length of the hinder leg of the former 1,275 mm. and for that of the latter 1,130 mm. The latter forms 88.6 per cent of the former. This indicates that the ratio of the length of the hind leg of *E. laurentius?* to that of the Arabian horse was greater than in the case of the foreleg.

In the Arabian horse the length of the foreleg is equal to 87 per cent of the length of the hind leg; in *E. laurentius?* the corresponding ratio drops to 84.2.

It can not be doubted that the owner of the two limbs here provisionally associated with *E. laurentius* was a horse considerably smaller than the Arabian with which it is here compared, himself not a large horse, and that this horse possessed a more heavily built skeleton than the Arabian had.

It may be profitable to institute a comparison between the fore limb of the Arabian horse and a fore limb numbered 7857 in the National Museum. It was found by Hatcher in the same quarry where were found the bones just described. From an examination of the table given on page 569 we gain the following results regarding the various bones of the Arabian as having the value of 100.

Relative measurements of bones of fore leg of Arabian horse and of the fossil No. 7857.

Bones compared.	Arabian.	No. 7857.
Humerus	100	94
Radius	100	93.2
Metacarpal 3	100	92.5
First phalange	100	95.2
Second phalange	100	102.8

The horse No. 7857, as indicated by the bones of the fore leg, was larger than the supposed *E. laurentius*, but yet smaller than the Arabian. By adding the lengths of the humerus, the radius, the third metacarpal, and the first phalange of each of the two horses there is obtained for the leg of the Arabian 975 mm. and for that of No. 7857, 911 mm. The latter forms 93.4 per cent of the former. This may be fairly taken as representing the relative lengths of the two legs and the relative heights of the two horses. The latter seems to have had a height of 13.25 hands, 53 inches, 1,347 mm.

The fore leg, which has the number 7923, found in the same quarry as the bones referred to *E. laurentius* and those having the number 7857, has a size not greatly different from that of the last one mentioned. The following table shows the results of a comparison of the length of the principal bones with those of the Arabian, those of the latter being regarded as having the value of 100.

Relative measurements of bones of Arabian horse and of a fossil horse.

Bones.	Arabian.	No. 7923.
Humerus	100	97.3
Radius	100	92.3
Metacarpal	100	100.0
First phalange	100	104.8
Second phalange	100	117.1

A comparison of the table just given with the one preceding it will show that the horse represented by the bones numbered 7923 belonged to a larger horse than those numbered 7857; the height was about 13.8 hands, 55.4 inches, 1,409 mm. It may be observed, too, that the metacarpal and the phalanges were, as measured by those of the Arab, longer than those of No. 7857.

For convenience in making comparisons a table is presented which combines the two immediately preceding tables with a part of the one on page 570.

Relative measurements of bones of Arabian horse, E. laurentius?, No. 7857, and No. 7923.

Bones.	Arabian.	*E. laurentius.*	No. 7857.	No. 7923.
Humerus	100	82.7	94.0	97.3
Radius	100	82.4	93.2	92.3
Metacarpal	100	88.7	92.5	100.0
First phalange	100	91.6	95.2	104.8
Second phalange	100	94.3	102.8	117.1

A direct comparison will now be made between the fore leg referred to *E. laurentius* and those of No. 7857 and of No. 7923, using the bones of the first named as standards of comparison.

Relative measurements of bones of E. laurentius?, of No. 7857, and of No. 7923.

Bones.	*E. laurentius?.*	No. 7857.	No. 7923.
Humerus	100	113.7	117.7
Radius	100	113.1	112.1
Metacarpal 3	100	104.2	113.1
First phalange	100	103.9	114.5
Second phalange	100	109.1	124.2

It is seen that all the bones of the numbers 7857 and 7923 are longer than the corresponding ones referred to *E. laurentius*. This table brings out well the differences among the three horses as displayed in the fore limb. In the case of 7857 the greatest difference between it and *E. laurentius?* is in the humerus; this disparity diminishes in the lower bones until the second phalange is reached. In No. 7923 the disparity in the length of the longer bones is greatest in the case of the humerus; it is reduced in the radius, but rises higher and higher in the lower bones.

The following table is taken from that given on page 569. Only the bones of the fore leg are considered, the humerus, the radius, the median metacarpal, and the first and second phalanges. In the case of each of these its length is regarded as being 100 and certain diameters are expressed in hundredths of this.

Showing diameters of bones in hundredths of the length.

Bones compared.	Arabian.	*E. laurentius?*	No. 7857.	No. 7923.
Humerus, length	100.0	100	100.0	100.0
Greatest width at upper end	41.0	36.3	31.9	34.2
Side-to-side diameter at middle	12.3	13.3	12.4	13.7
Diameter across lower end	26.7	29.4	27.6	28.4
Radius, length	100.0	100.0	100.0	100.0
Greatest width at upper end	24.2	27.2	26.5	28.0
Fore-and-aft diameter at middle	8.2	9.8	8.8	10.1
Side-to-side diameter at middle of length	11.3	14.1	13.1	13.8
Greatest width near lower end	22.7	23.8	22.5	24.8
Width of distal articular surface	19.0	20.0	19.8	21.8
Median metacarpal, length	100.0	100.0	100.0	100.0
Side-to-side diameter of upper end	22.5	23.4	23.4	22.8
Fore-and-aft diameter at middle of length	11.7	12.6	13.1	13.2
Side-to-side diameter at middle of length	12.1	15.9	16.0	16.6
Side-to-side diameter at lower end	22.1	22.0	23.4	22.0
First phalange, length	100.0	100.0	100.0	100.0
Width of upper end	65.9	71.0	78.4	70.1
Width of middle of length	41.2	47.3	43.0	46.0
Width at lower articular surface	55.2	56.6	59.5	59.7
Second phalange, length	100.0	100.0	100.0	100.0
Width of upper end	157.1	133.0	152.8	144.0
Width of middle of length	134.2	124.0	127.7	122.0
Width across lower articular surface	154.3	130.3	141.7	129.2

A study of the tables just presented shows that there is, among the bones of the four limbs measured, a considerable amount of differences, not only in length but in proportions. The humerus of *E. laurentius?* is shorter than either of the other two fossil forms; it is also thicker at the ends, while the diameter at the middle of the bone is, relatively to the length, greater than in No. 7857, less than in No. 7923. On comparing the humeri of the numbers just mentioned it is seen that the first mentioned is slenderer than the others.

The radius also of *E. laurentius?* is shorter than it is in the other two limbs, whose radii are of about equal length. That of *E. laurentius?* is intermediate in its diameter between the other two in the first, second, and fourth measurements. As regards No. 7857 and 7923, the radius of the latter is in all respects a stouter bone.

The median metacarpals of the three fossil limbs are much alike in their proportions and there are relatively small differences in their absolute lengths. That of *E. laurentius* is slightly slenderer than those of the other two. As compared with the Arabian horse, the three fossil forms have the metacarpals considerably stouter.

The first phalange of *E. laurentius?* is shorter than that of each of the other two limbs. That of No. 7857 is relatively broader at the ends and more constricted at the middle. In all three the bone is heavier than it is in the Arabian horse.

Greater differences in proportions are found among the second phalanges; it is possible that these short bones, broader than long, afford greater individual variations than the longer bones.

To the writer it appears that the measurements of the limb bones above recorded indicate with considerable certainty that there existed in the region of northwestern Nebraska, in the early part of the Pleistocene, at least three distinct species of horses; and that thus are confirmed conclusions which have been derived from studies of skulls and teeth. It is to be hoped that soon limbs may be found associated with skulls.

EXPLANATION OF PLATES.

PLATE 30.

Bison sylvestris. Type.

FIG. 1. Right hinder angle of skull, seen from above. $\times\frac{1}{2}$.

2. Left side of rear of skull, seen from below. $\times\frac{1}{2}$.

1. Basioccipital. 2. Petrosal. 3. Basisphenoid. 4. Alisphenoid. 5. Pterygoid processes. 6. Occipital condyles. 7. Base of paroccipital process. 8. Cavity into which opens the condylar foramen. 9. Foramen lacerum posterius. 10. External auditory meatus. 11. Postglenoid foramen. 12. Glenoid fossa. 13. Foramen lacerum medius. 14. Foramen ovale, confluent with 13. 15. Bar of bone forming floor of foramen lacerum anterius.

3. Outer face of last premolar and two molars of right side of lower jaw. $\times 1$.

4. Inner face of the same teeth. $\times 1$.

PLATE 31.

Boötherium nivicolens. Type. $\times\frac{1}{4}$.

FIG. 1. Face view of forehead and horn-cores.

Boötherium sargenti. Type. $\times .36$.

2. Side view of skull.

PLATE 32.

Equus hatcheri. Type. $\times\frac{1}{4}$.

Side view of skull.

PLATE 33.

Equus hatcheri. Type. $\times\frac{1}{4}$.

FIG. 1. Face view of the skull.

2. Palatal view of the skull.

PLATE 34.

Equus hatcheri. Type. $\times\frac{3}{4}$.

FIG. 1. Grinding surface of the upper premolars and molars.

2. Grinding surface of lower premolars and molars.

PLATE 35.

Equus francisci. Type.

FIG. 1. Side view of the skull. $\times\frac{1}{3}$.

2. Upper molars and premolars. $\times 1$.

PLATE 36.

Equus francisci. Type. $\times\frac{1}{3}$.

FIG. 1. Face view of skull.

2. Palatal view of skull.

PLATE 37.

Equus francisci. Type.

FIG. 1. Lower jaw. $\times\frac{1}{3}$.

2. Last premolar and the molars of right side. $\times 1$.